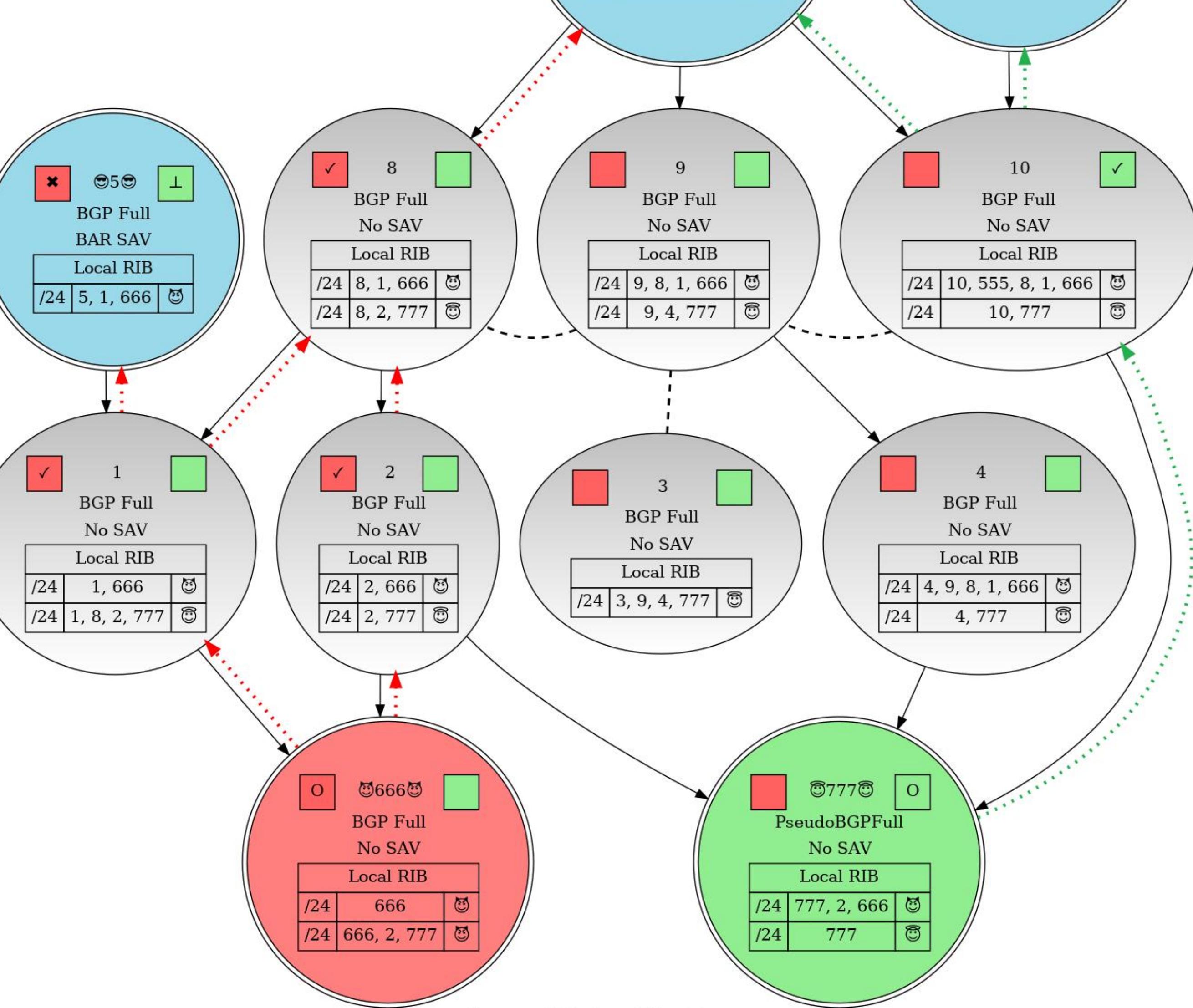


(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



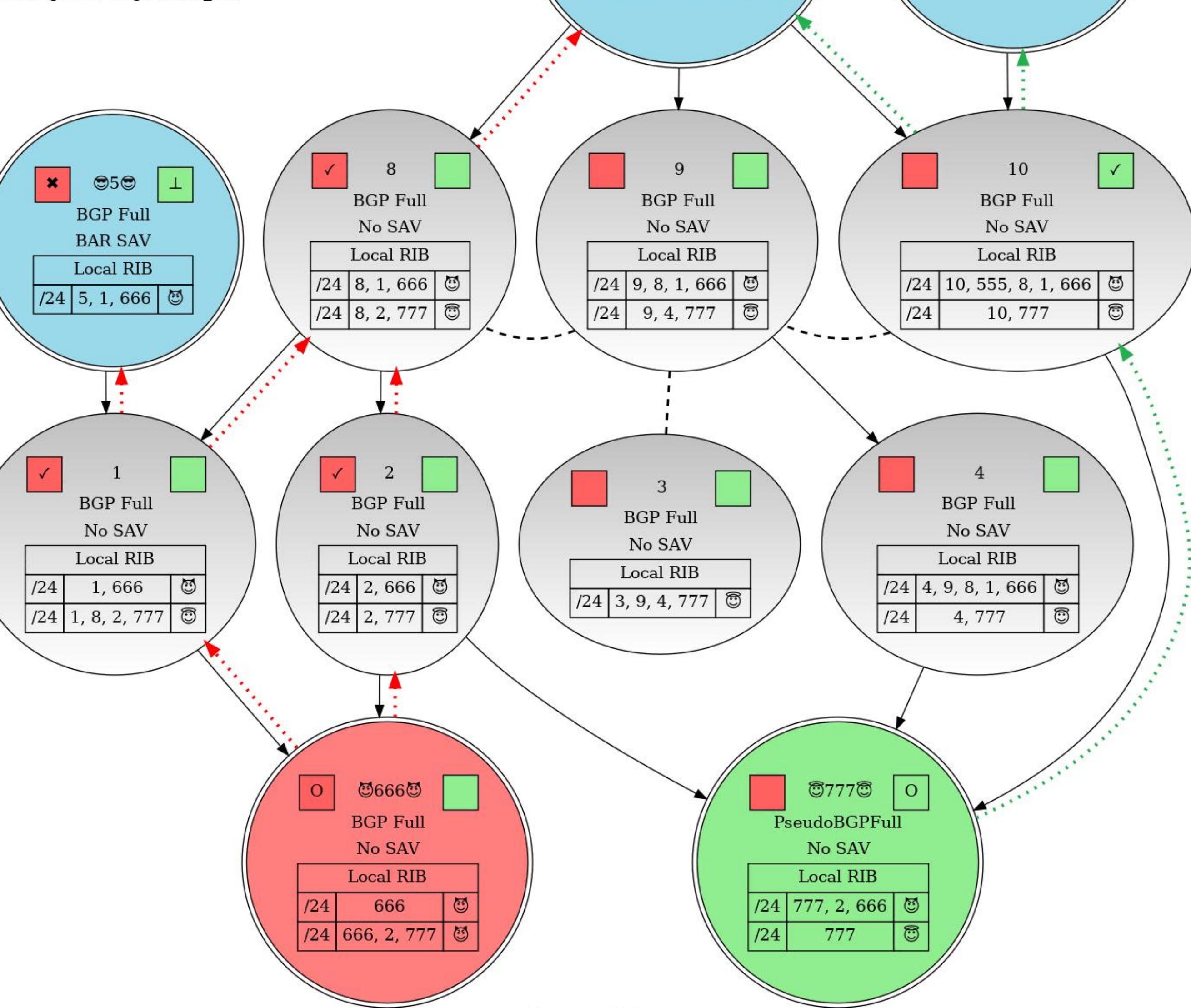
(bar_sav_000 Ground Truth)
Three reflectors running BAR SAV, one disconnected from both victim and attacker

(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



(bar_sav_000)

Three reflectors running BAR SAV, one disconnected from both victim and attacker

(Data Plane Outcomes)

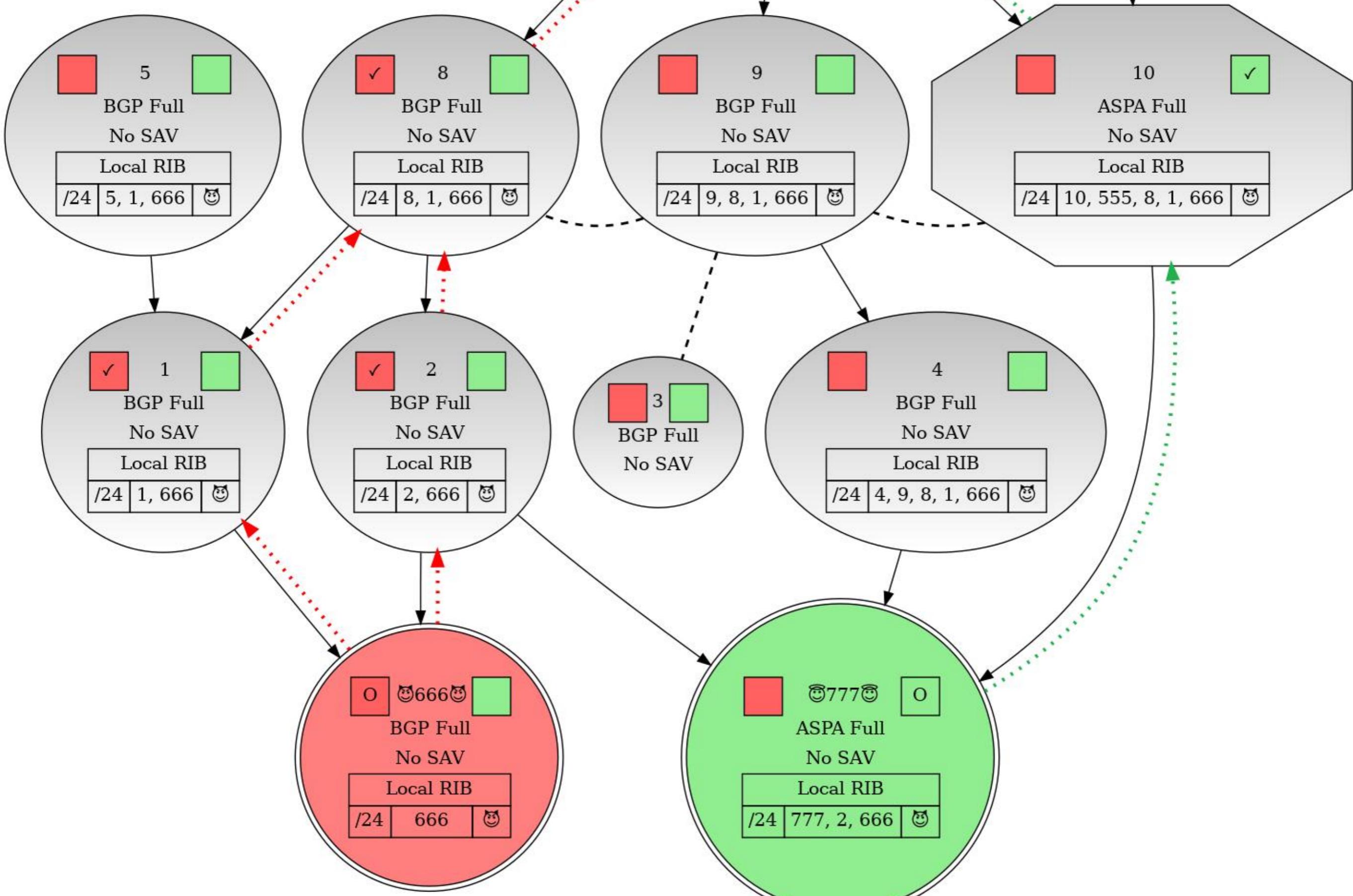
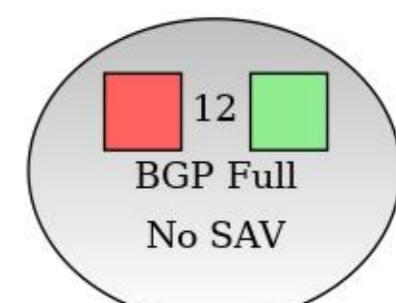
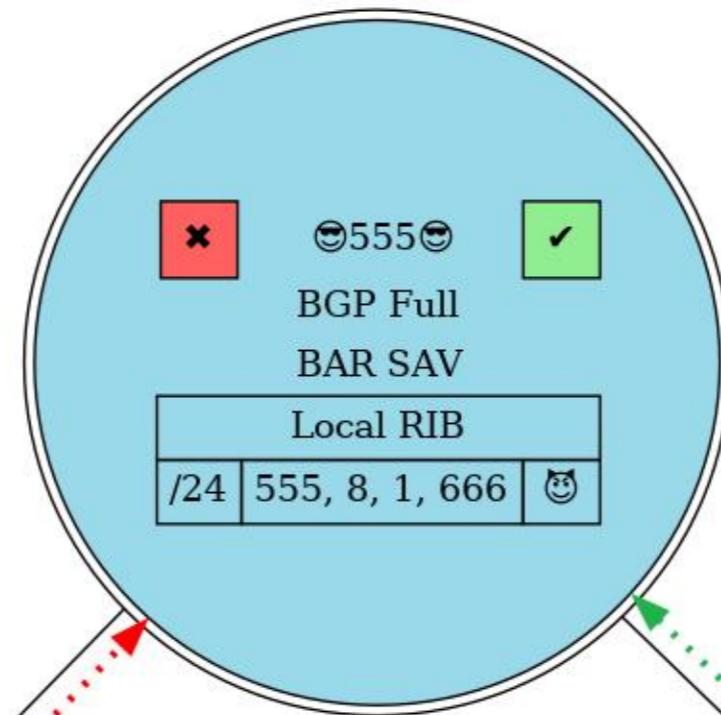
(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)

7.7.7.0/24 | 777 | 24

(Victim Outcomes)



(bar_sav_001 Ground Truth)
Single reflector running BAR SAV, victim does not announce prefix

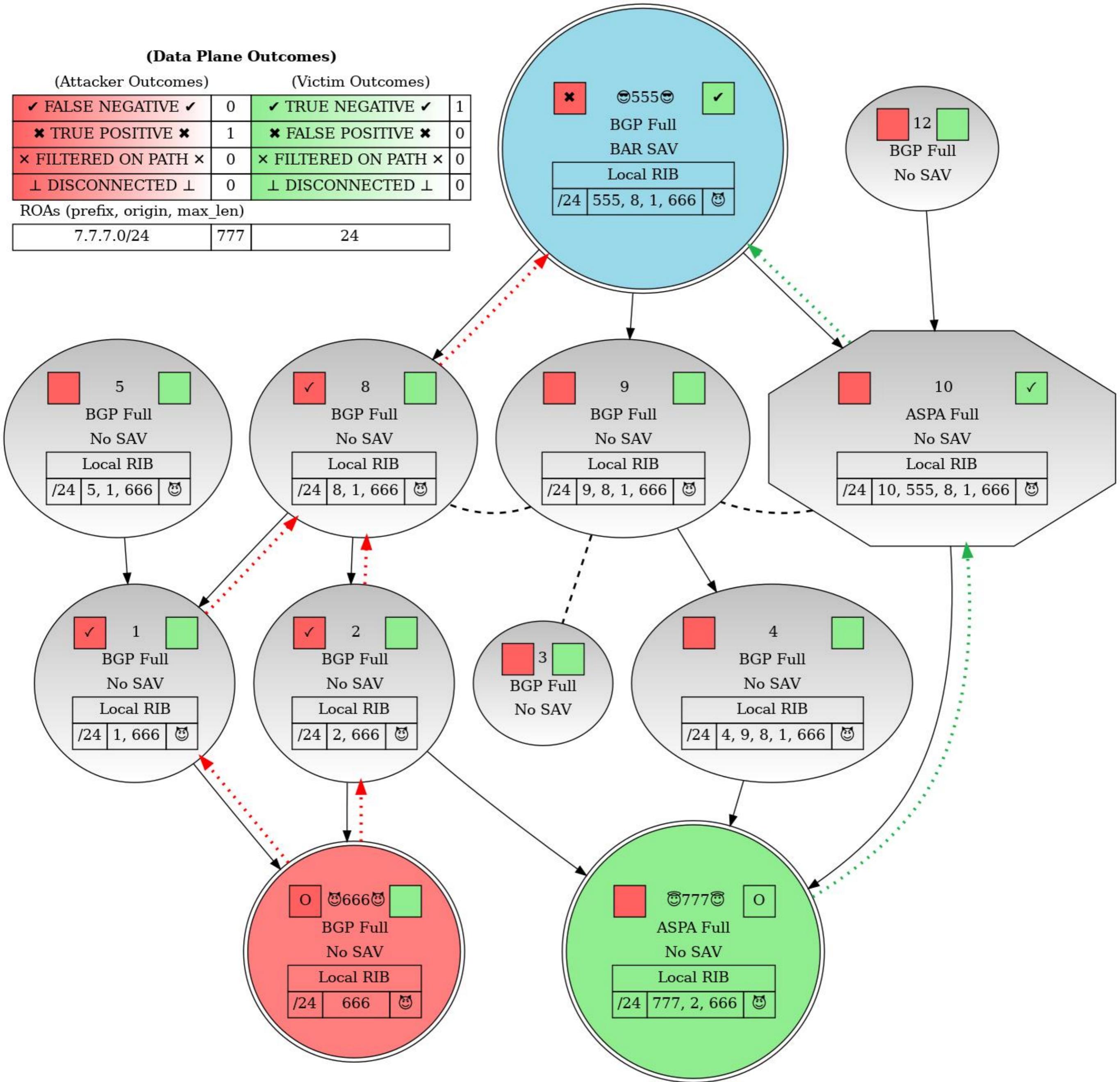
(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)

7.7.7.0/24	777	24
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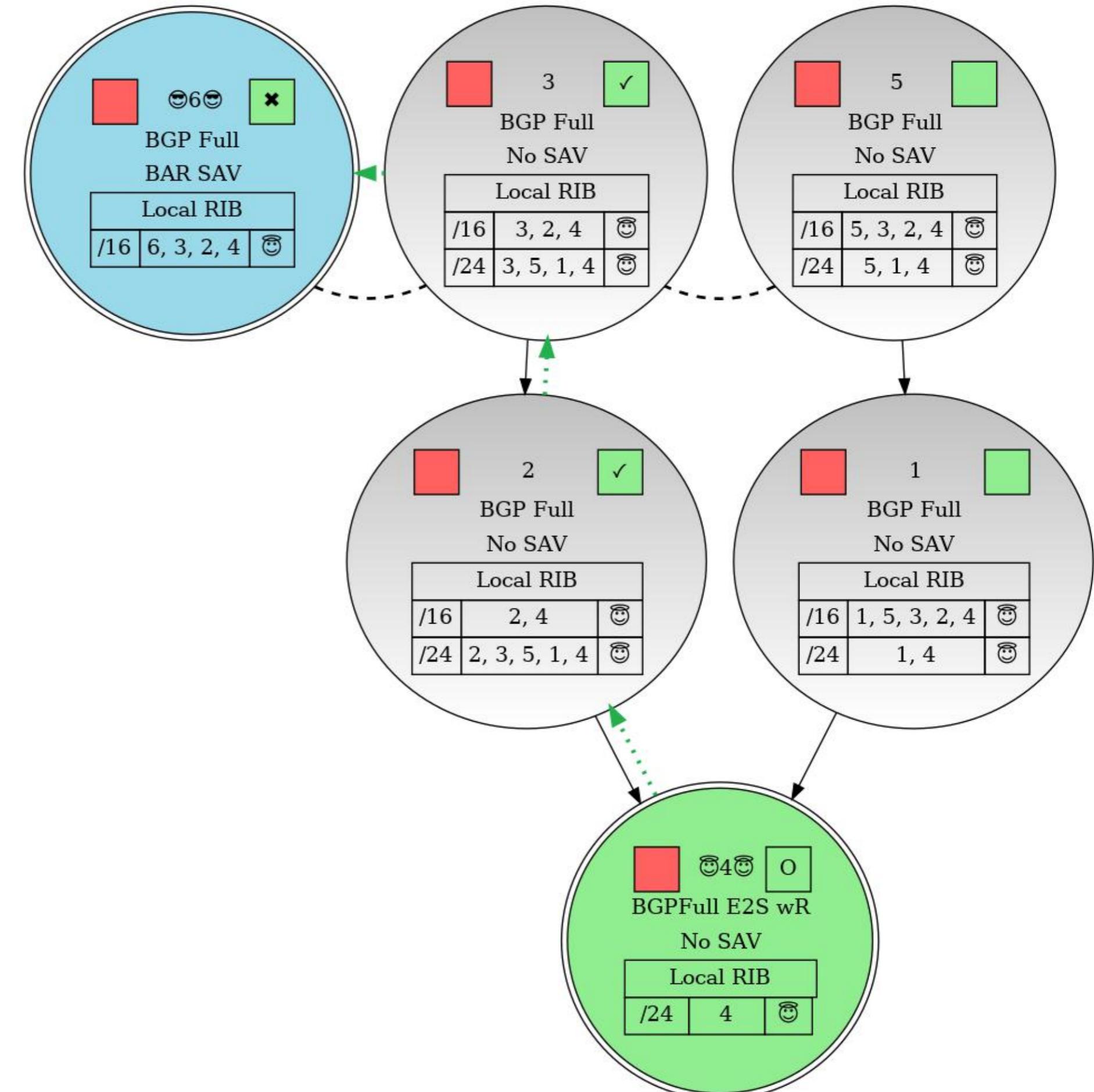
(bar_sav_001)
Single reflector running BAR SAV, victim does not announce prefix

(Data Plane Outcomes)

(Attacker Outcomes)

	(Victim Outcomes)		
✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



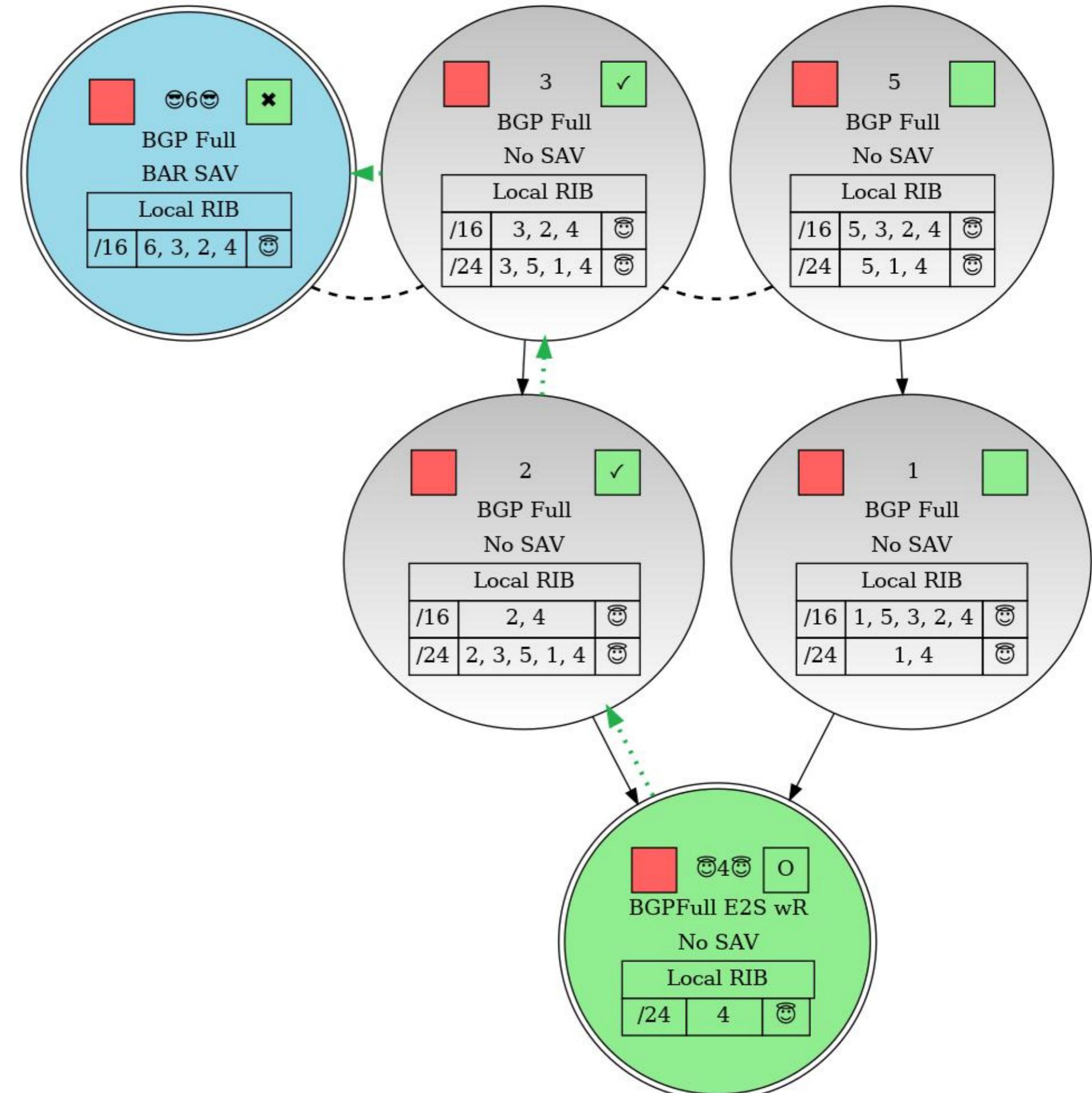
(bar_sav_005 Ground Truth)
BAR SAV False Positive Test No ROA

(Data Plane Outcomes)

(Attacker Outcomes)

	(Victim Outcomes)	
	✓ FALSE NEGATIVE ✓	✓ TRUE NEGATIVE ✓
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗ 1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗ 0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥ 0

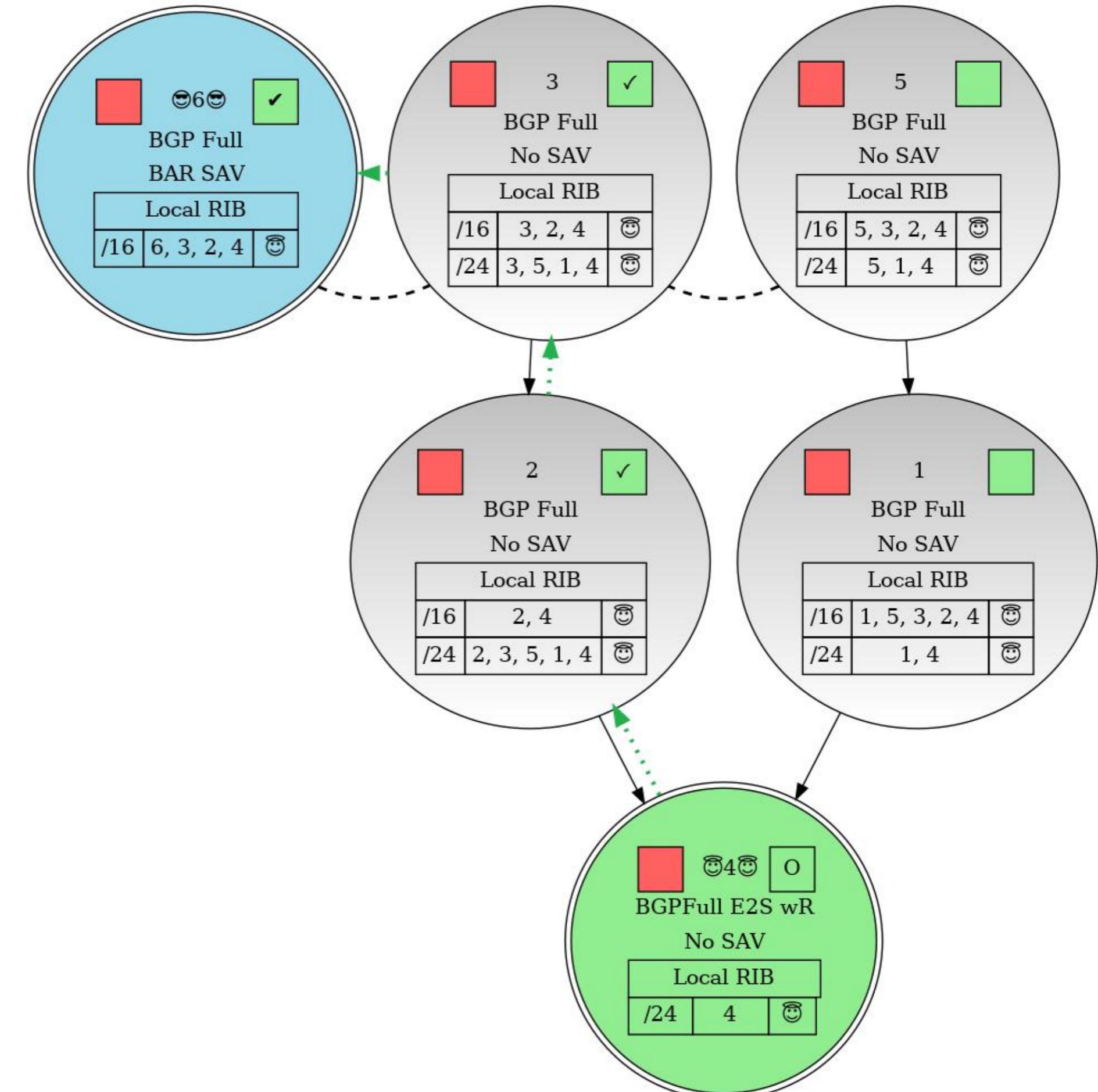
ROAs (prefix, origin, max_len)



(bar_sav_005)
BAR SAV False Positive Test No ROA

(Data Plane Outcomes)

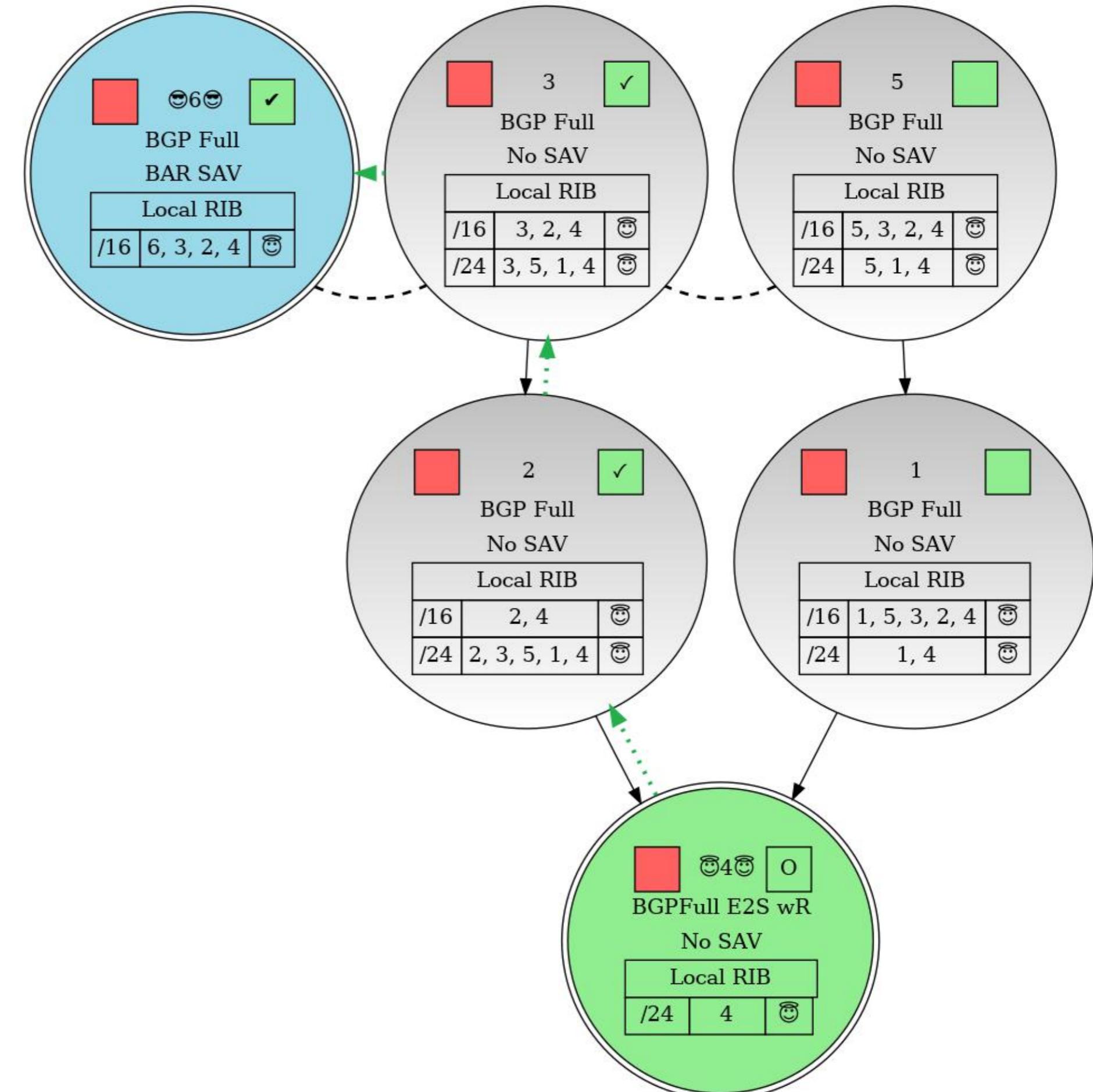
(Attacker Outcomes)		(Victim Outcomes)	
✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0
ROAs (prefix, origin, max_len)			
7.7.7.0/24	4	24	



(bar_sav_006 Ground Truth)
BAR SAV False Positive Test with ROA (Expecting True Negative)

(Data Plane Outcomes)

(Attacker Outcomes)		(Victim Outcomes)	
✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0
ROAs (prefix, origin, max_len)			
7.7.7.0/24	4	24	



(bar_sav_006)
BAR SAV False Positive Test with ROA (Expecting True Negative)

(Data Plane Outcomes)

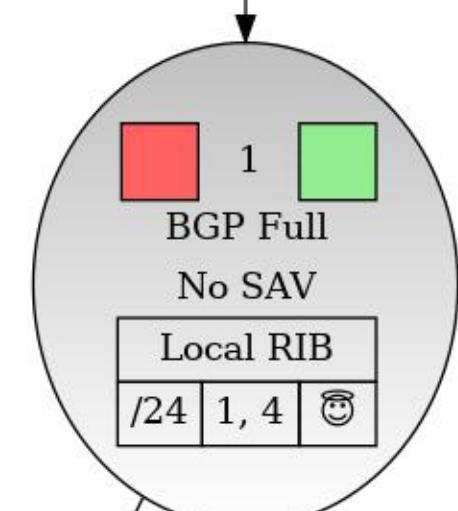
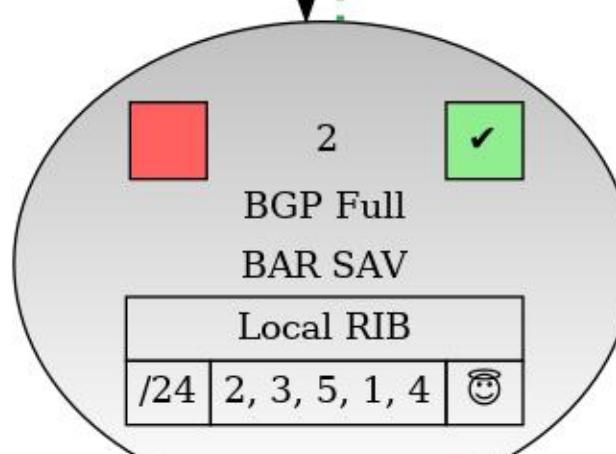
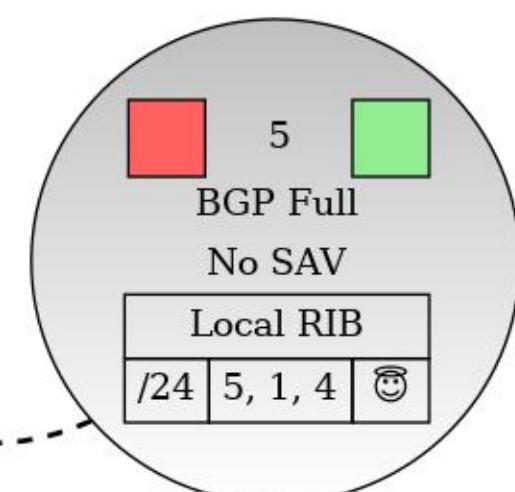
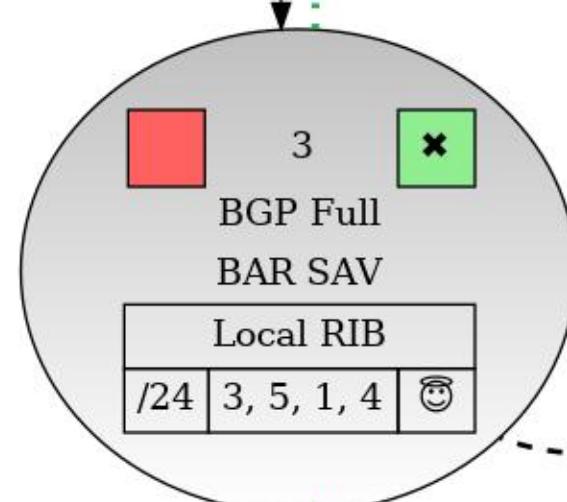
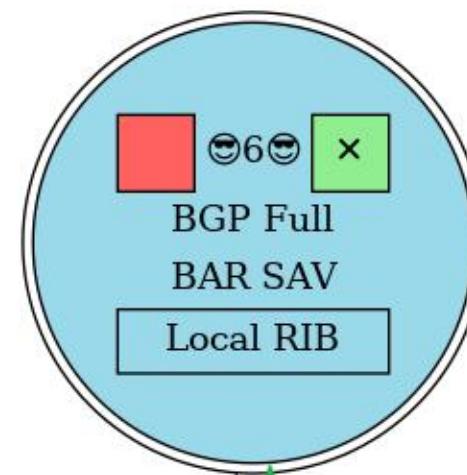
(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	1
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

(Victim Outcomes)

ROAs (prefix, origin, max_len)

7.7.7.0/24	4	24
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(bar_sav_007 Ground Truth)
BAR SAV False Positive Test with ROA

(Data Plane Outcomes)

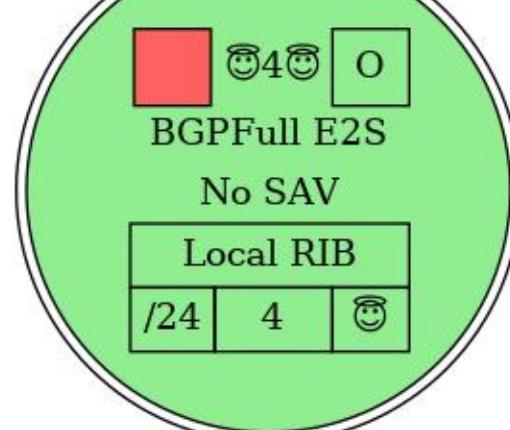
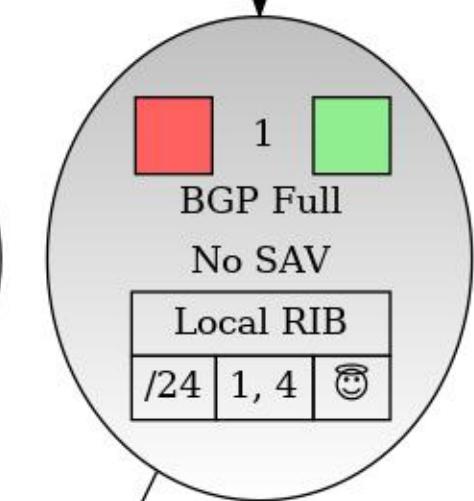
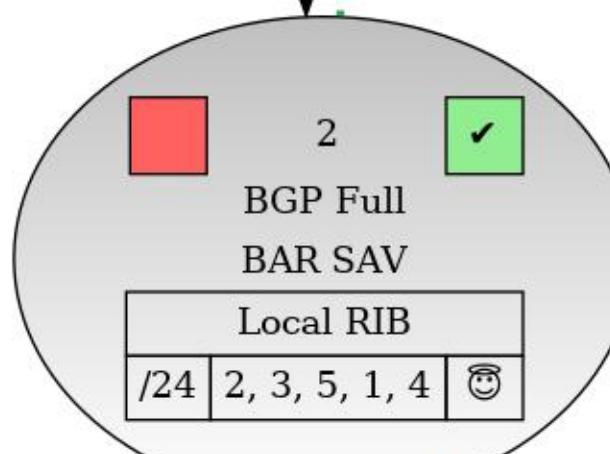
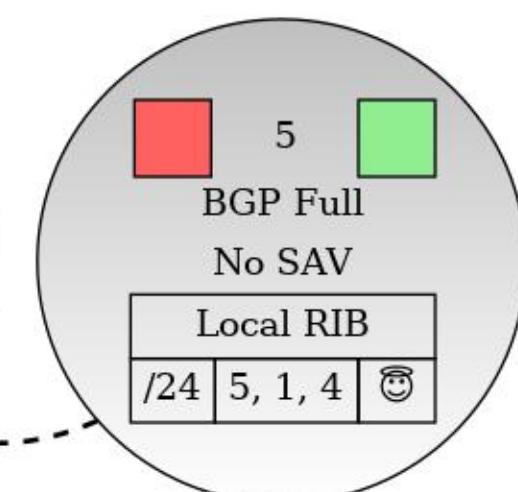
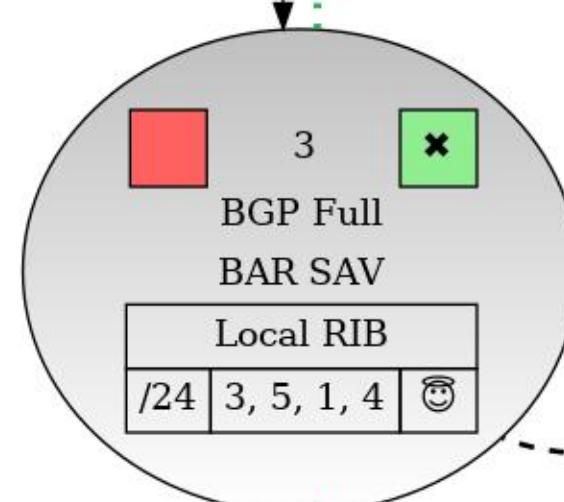
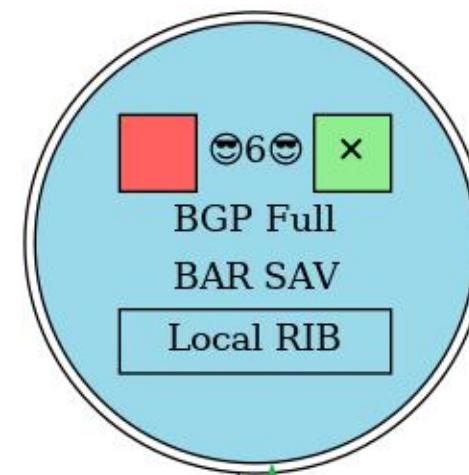
(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	1
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

(Victim Outcomes)

ROAs (prefix, origin, max_len)

7.7.7.0/24	4	24
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(bar_sav_007)
BAR SAV False Positive Test with ROA

(Data Plane Outcomes)

(Attacker Outcomes)

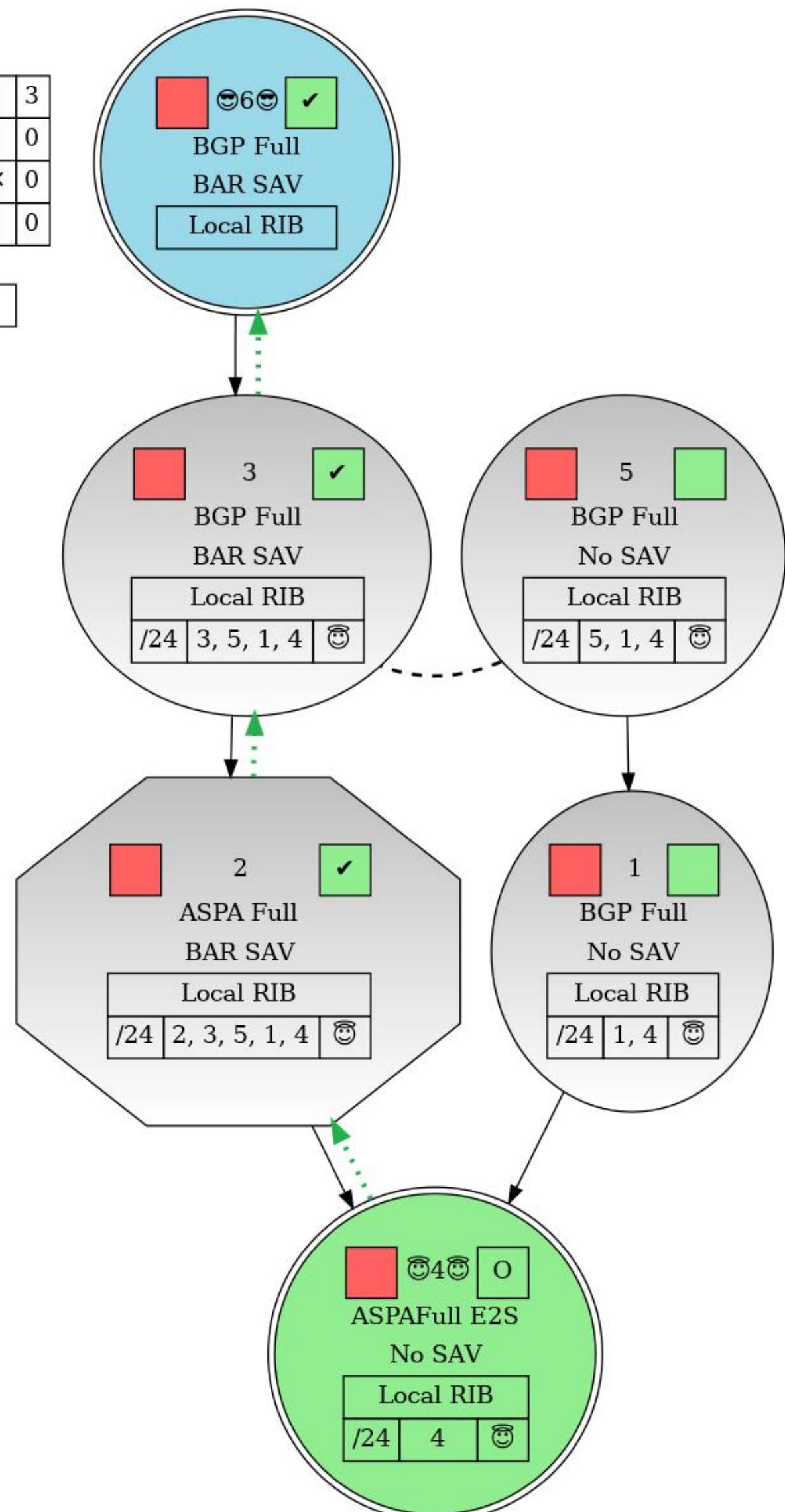
✓ FALSE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0

(Victim Outcomes)

✓ TRUE NEGATIVE ✓	3
✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)

7.7.7.0/24	4	24
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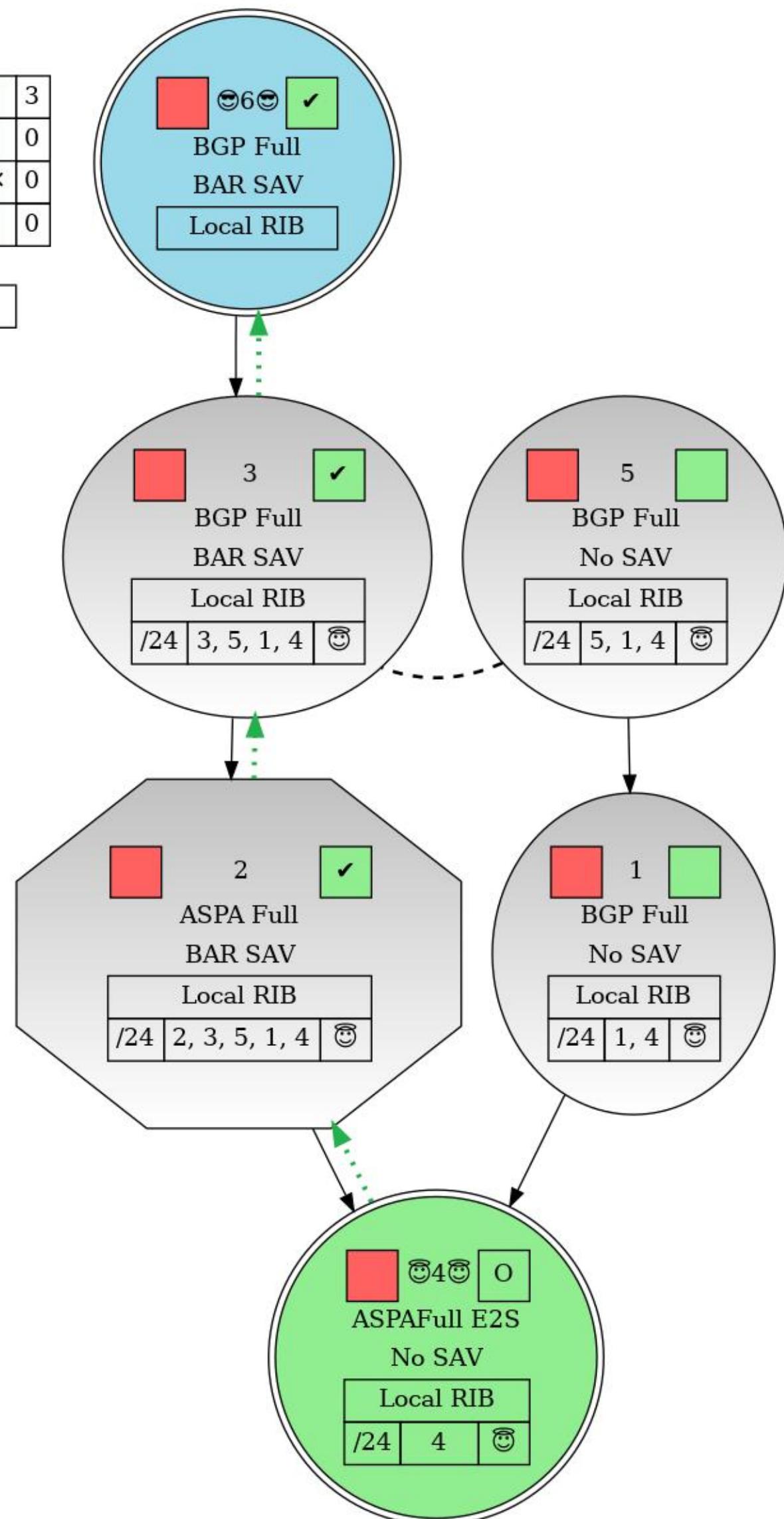
(bar_sav_008 Ground Truth)
BAR SAV False Positive Test with ROA and ASPA (Expecting True Negative)

(Data Plane Outcomes)

(Attacker Outcomes)		(Victim Outcomes)	
✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	3
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)

7.7.7.0/24	4	24
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(bar_sav_008)

BAR SAV False Positive Test with ROA and ASPA (Expecting True Negative)

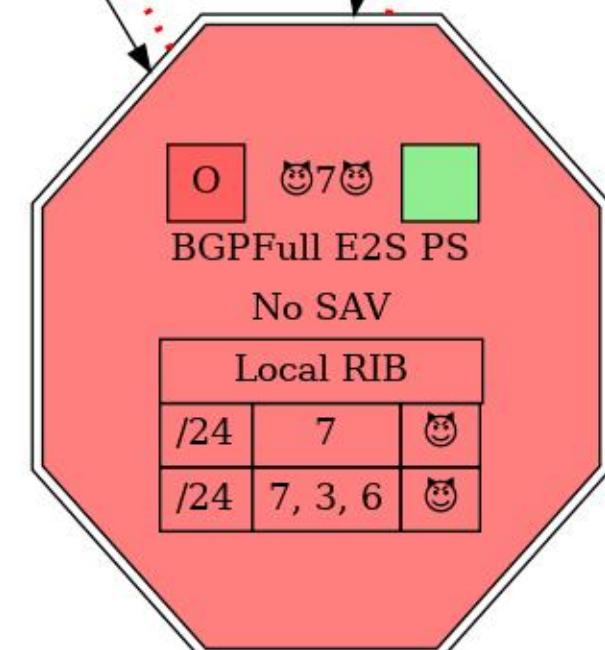
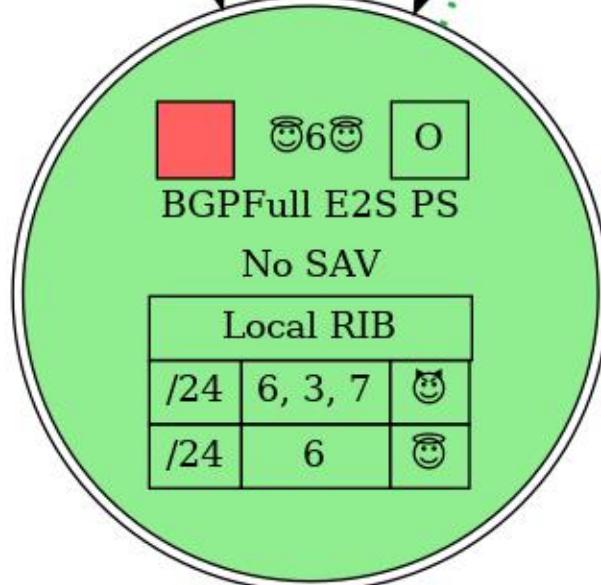
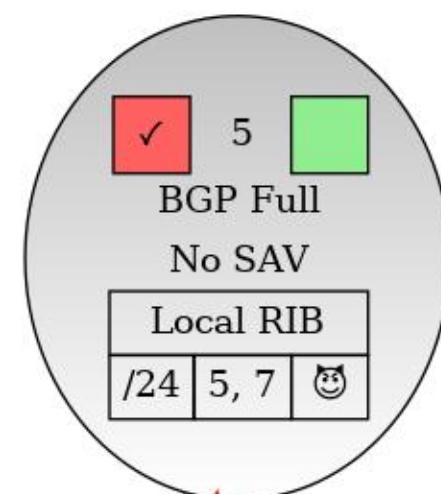
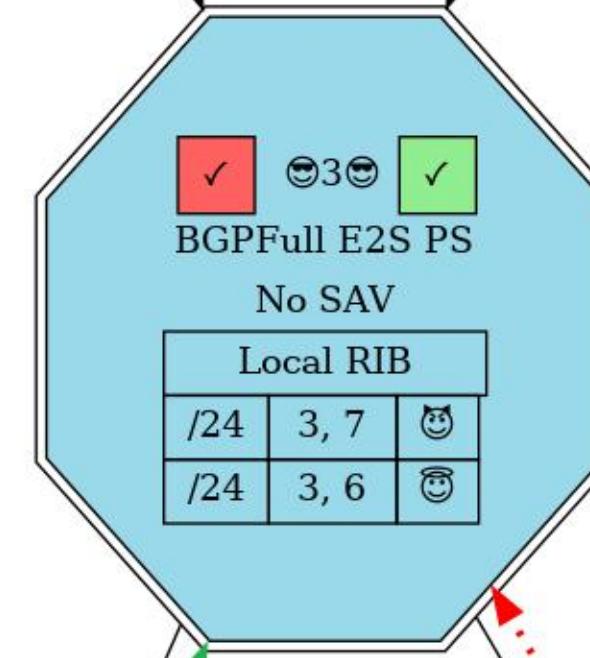
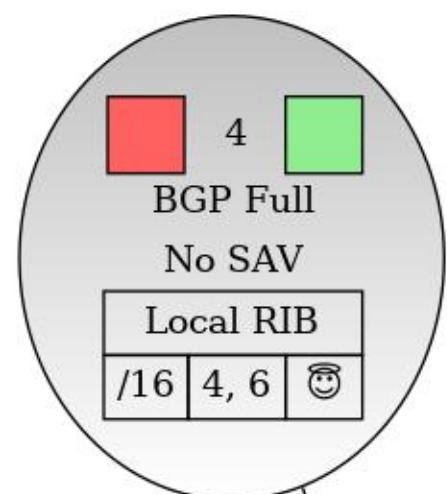
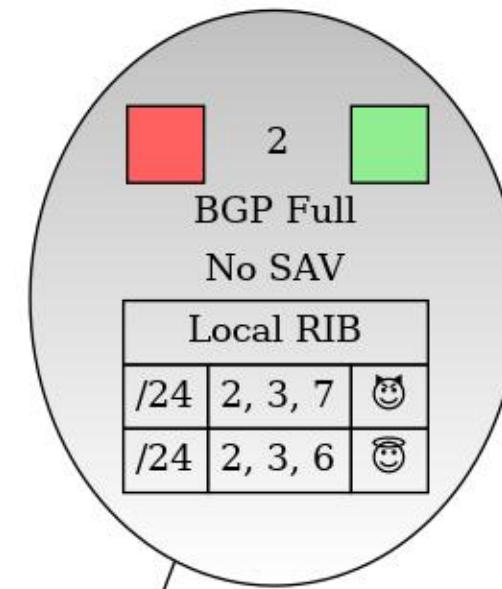
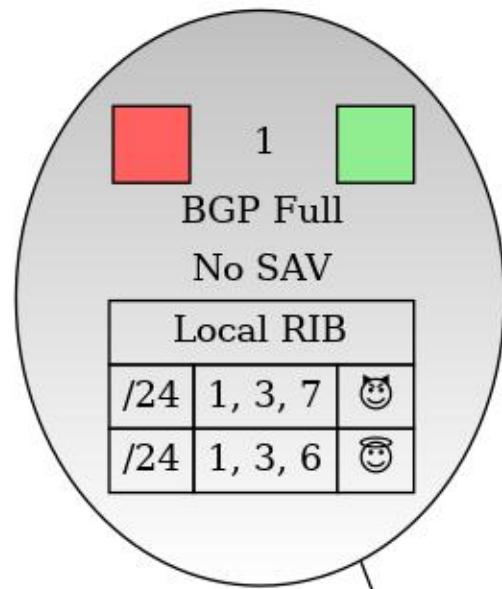
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(e2s_ps_000 Ground Truth)
Prefix Specific Export-to-Some

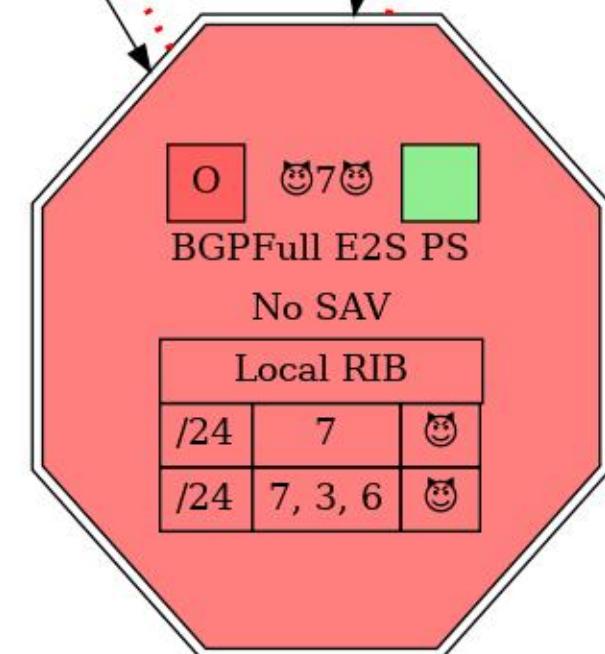
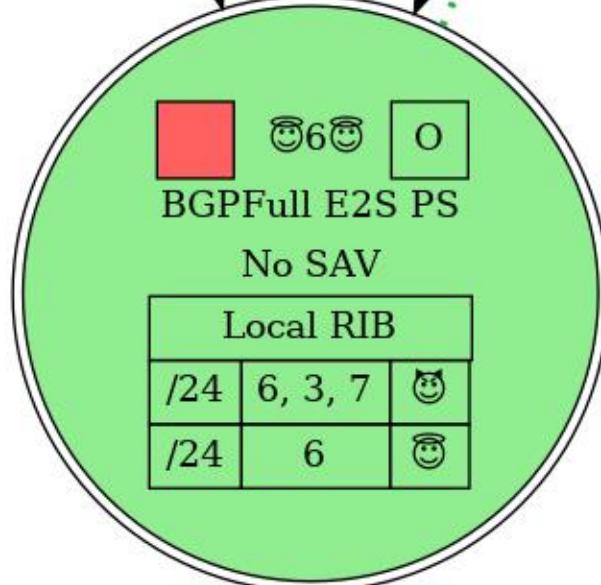
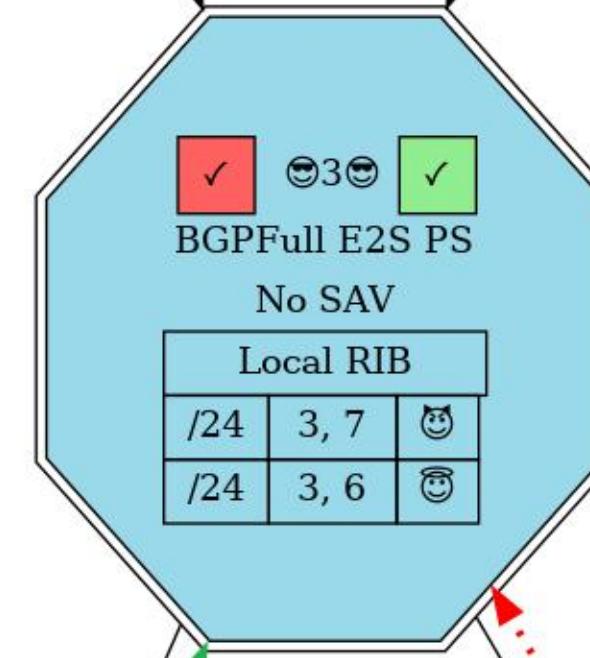
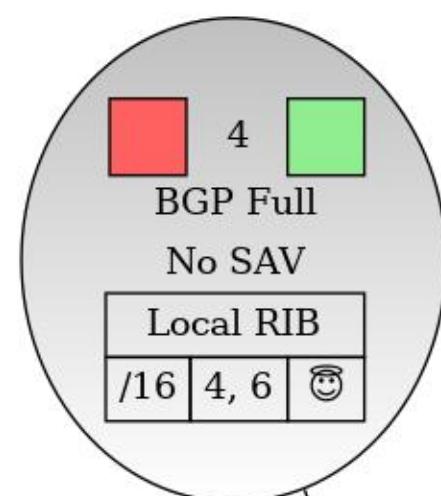
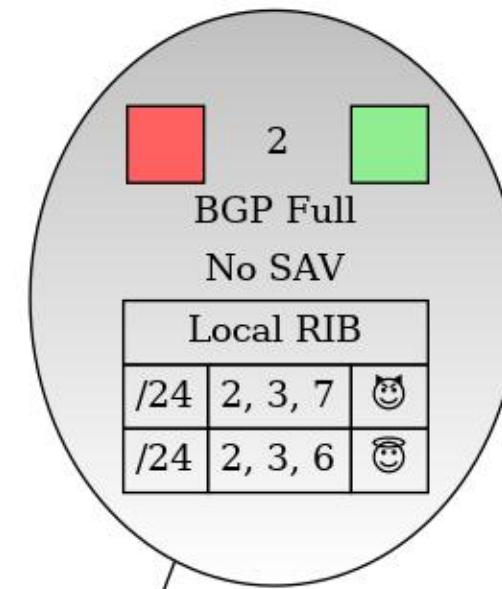
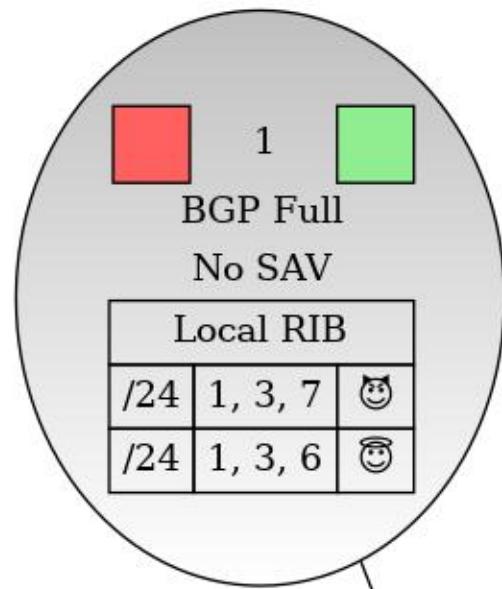
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(e2s_ps_000)
Prefix Specific Export-to-Some

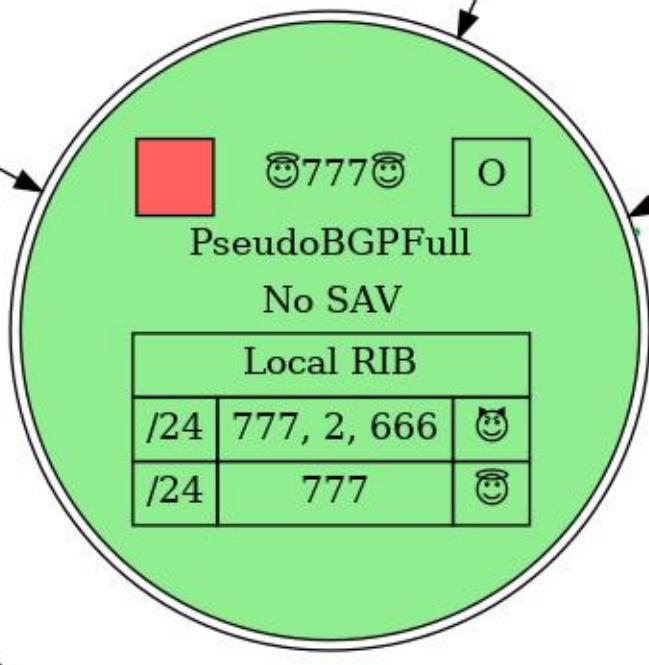
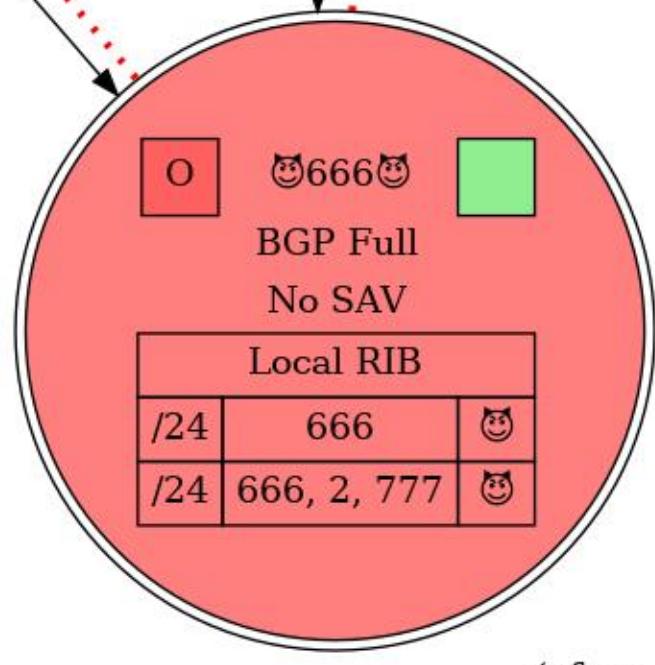
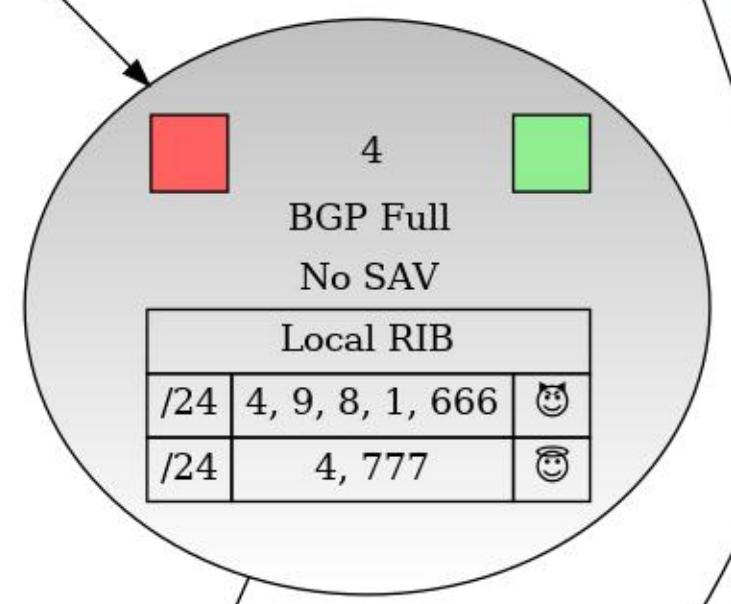
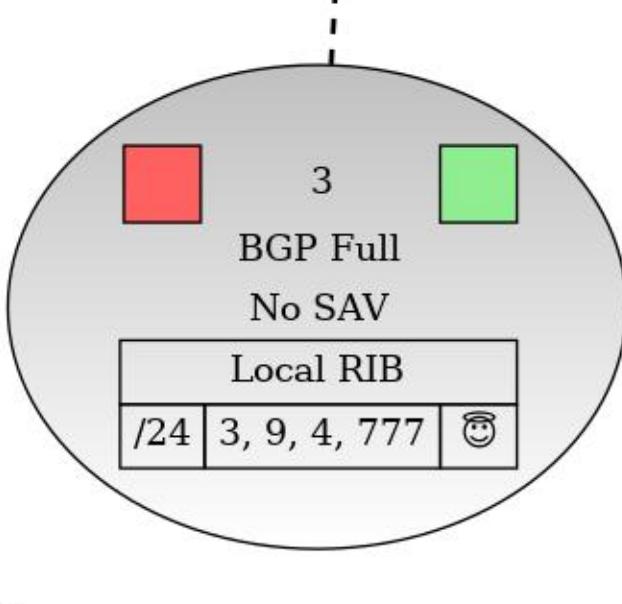
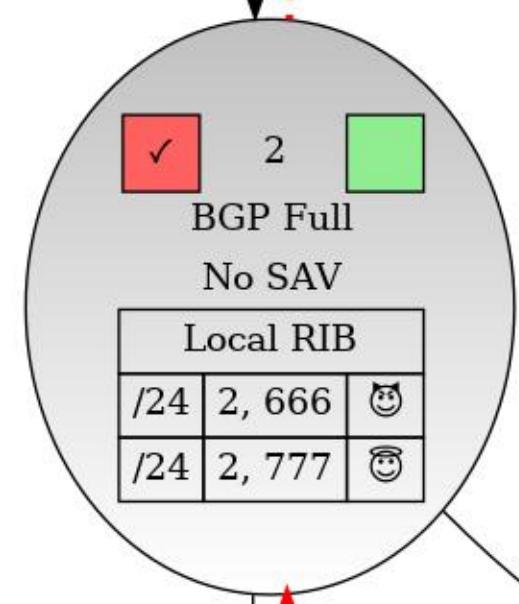
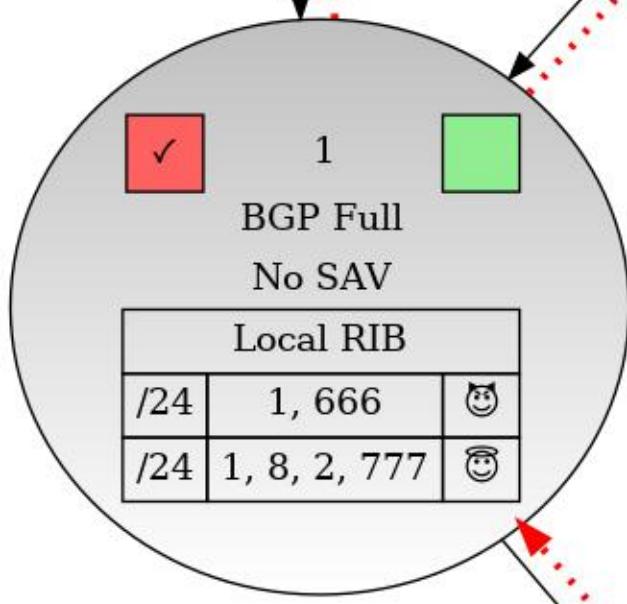
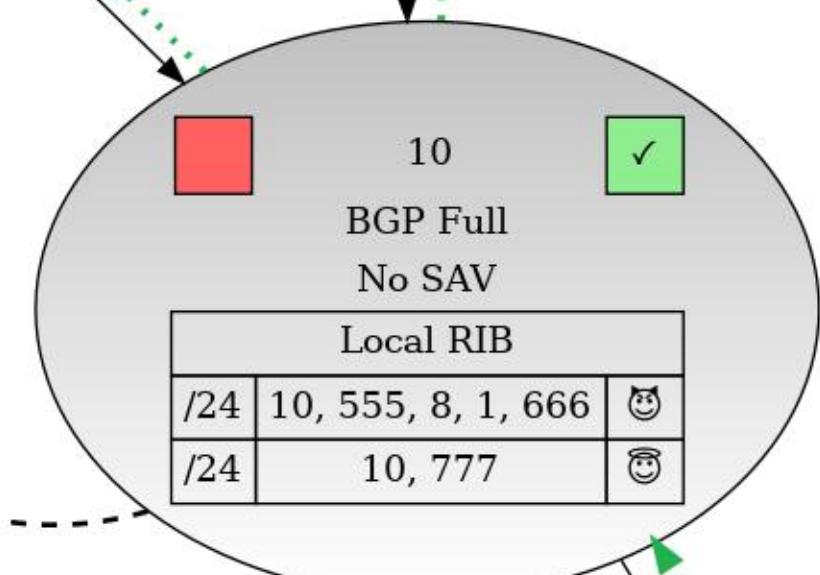
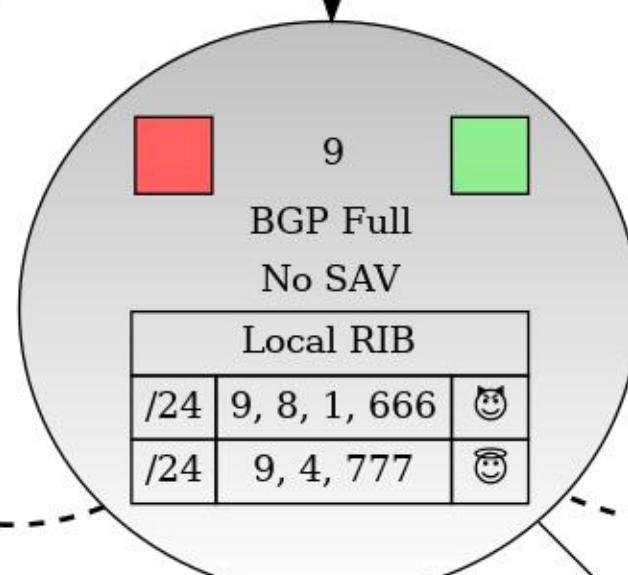
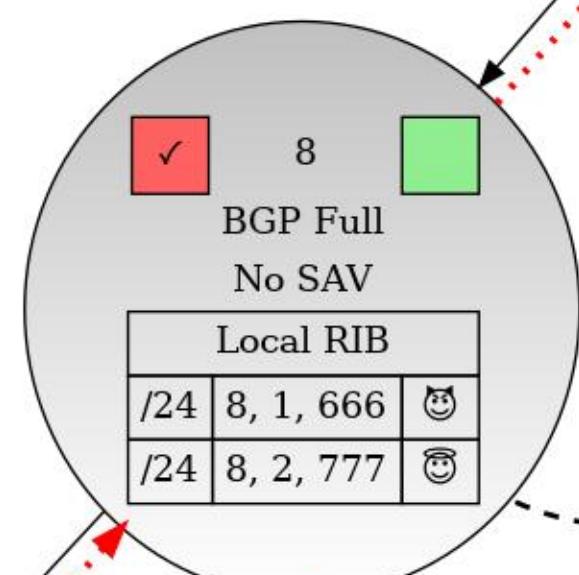
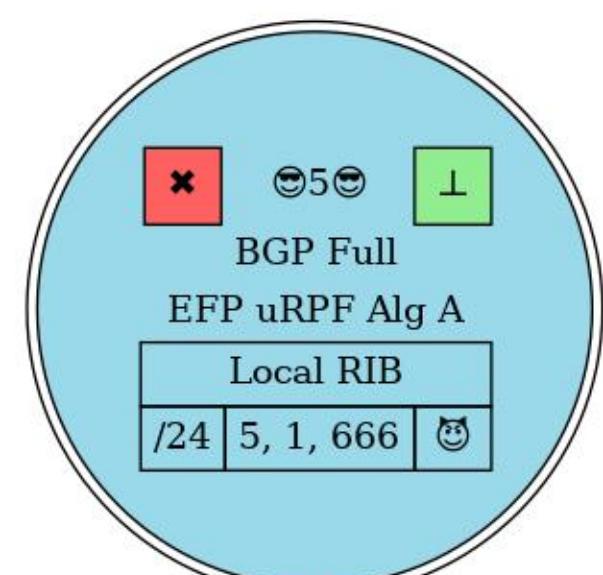
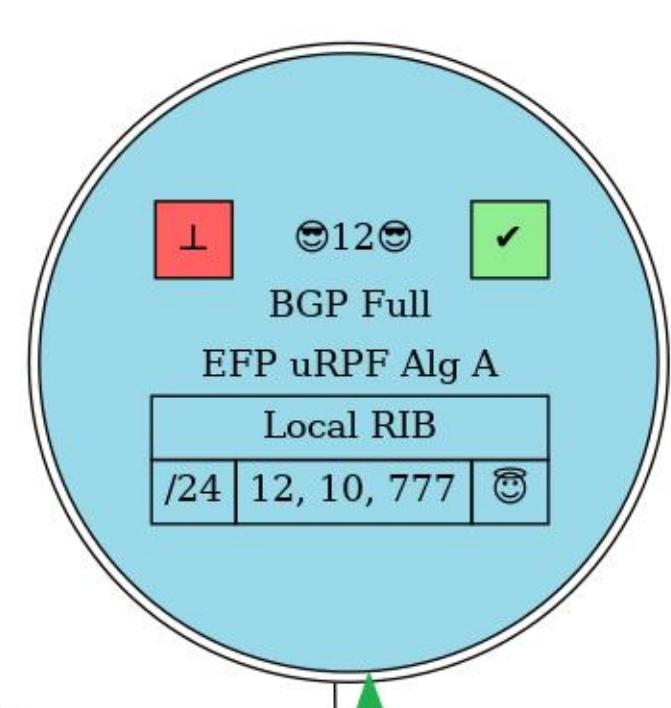
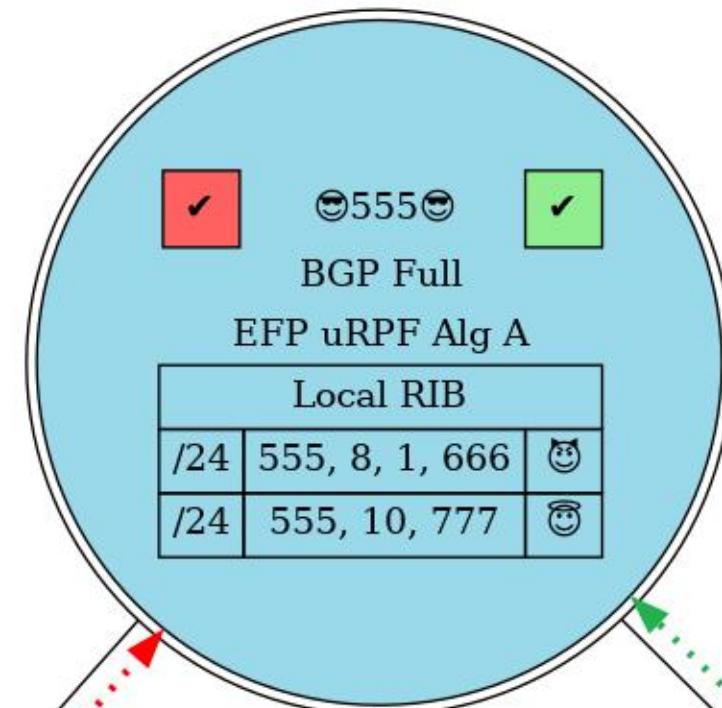
(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)

(Victim Outcomes)



(efp_a_000 Ground Truth)

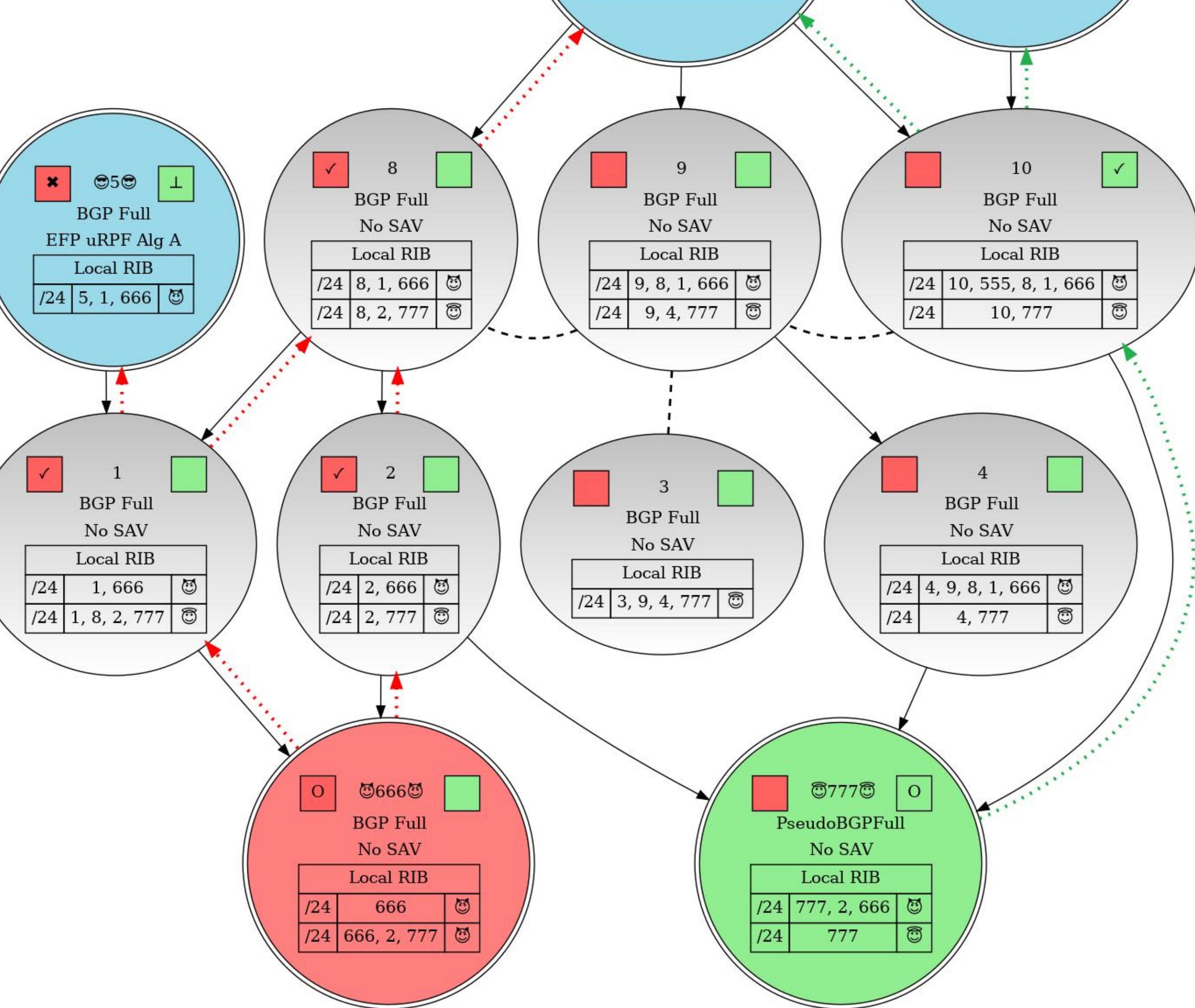
Three reflectors running EFP uRPF Alg A, one disconnected from both victim and attacker

(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



(efp_a_000)

Three reflectors running EFP uRPF Alg A, one disconnected from both victim and attacker

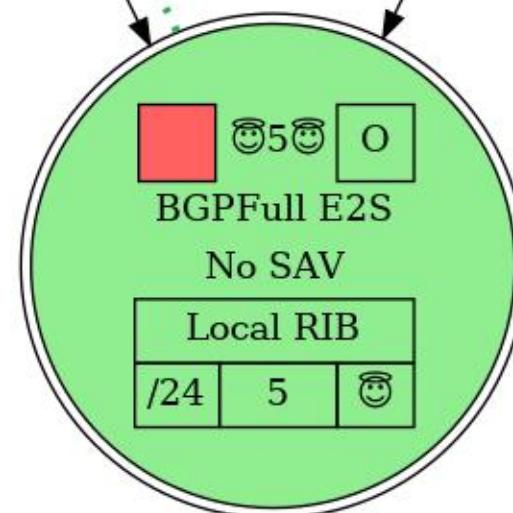
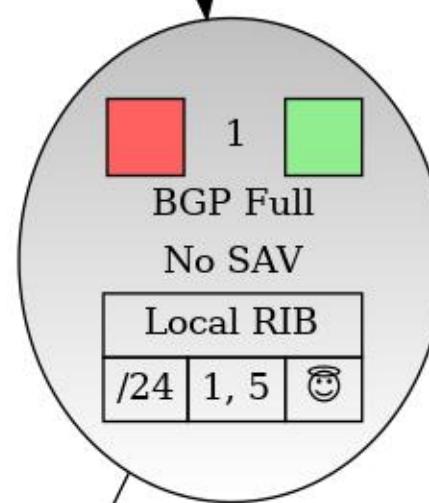
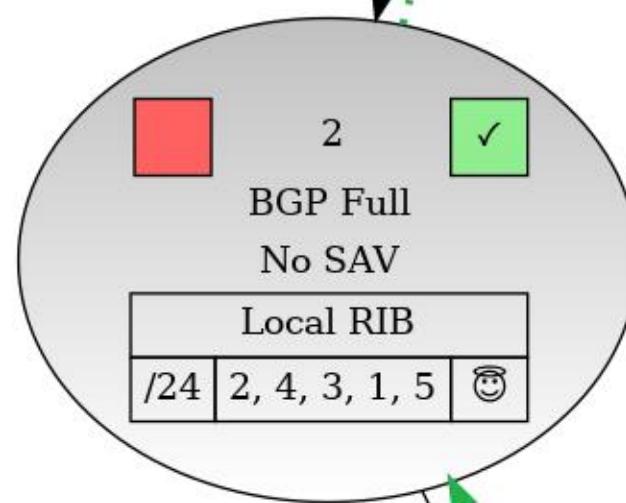
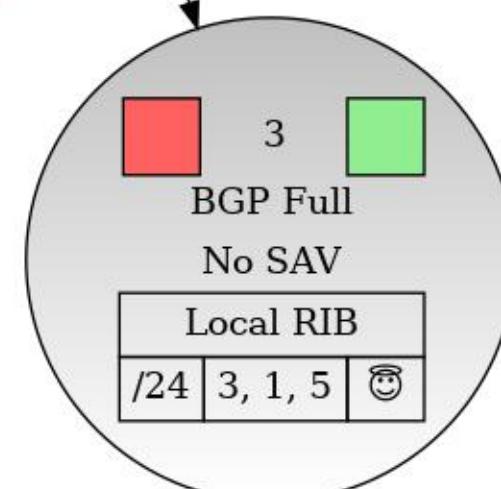
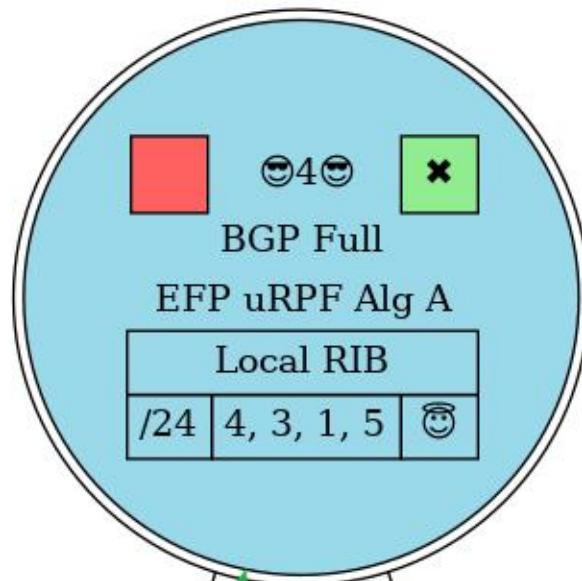
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(efp_a_001 Ground Truth)
Export 2 some failing for EFP Alg A

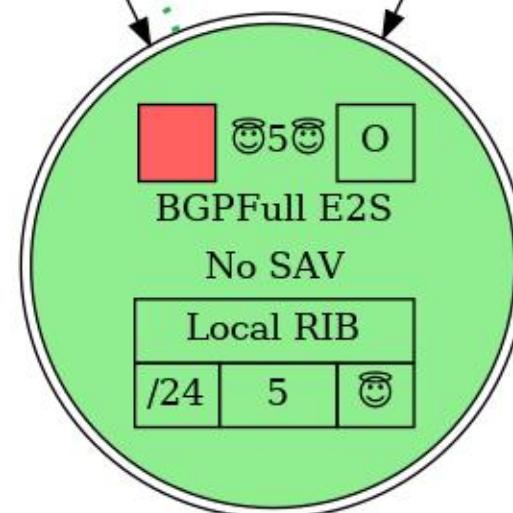
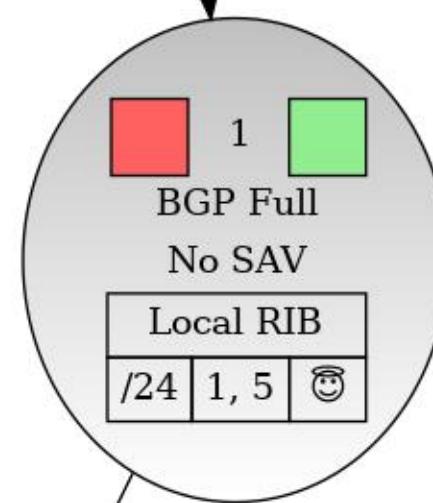
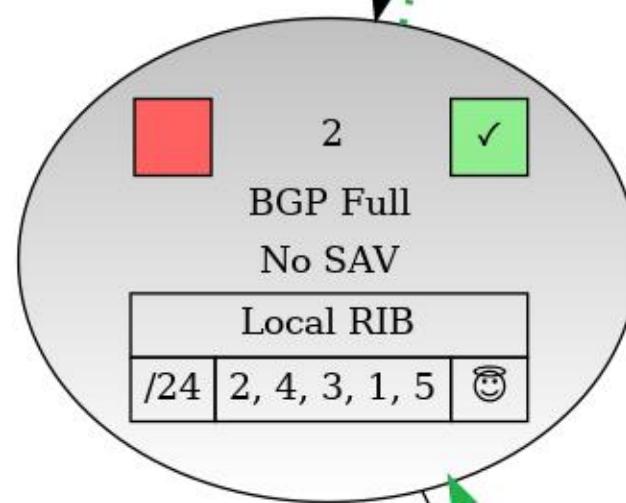
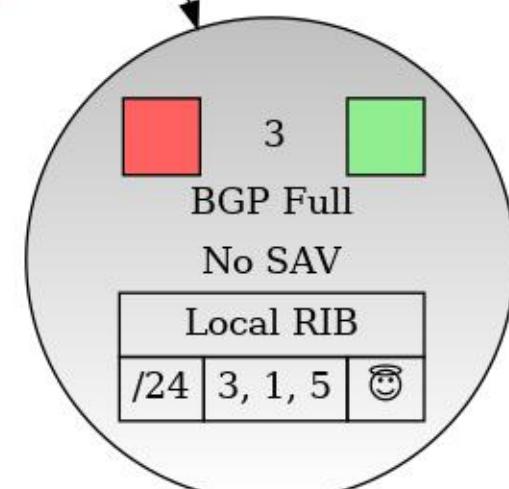
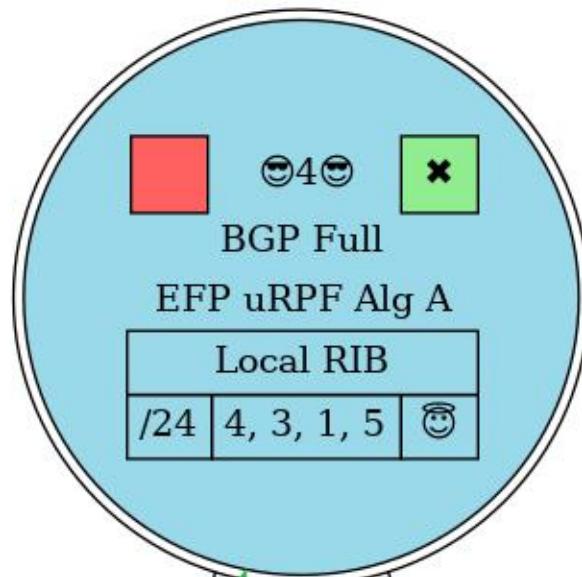
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(efp_a_001)
Export 2 some failing for EFP Alg A

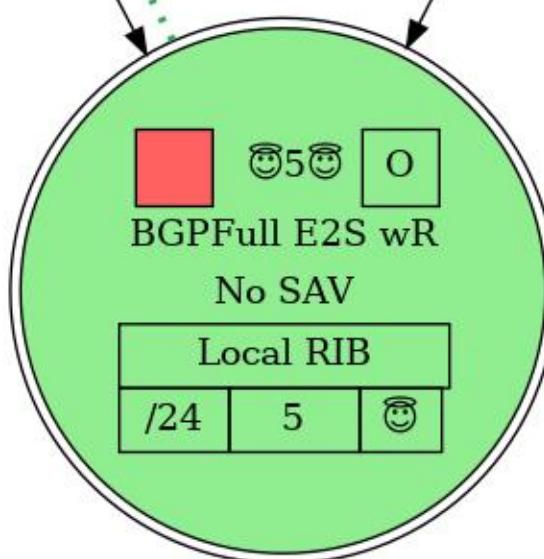
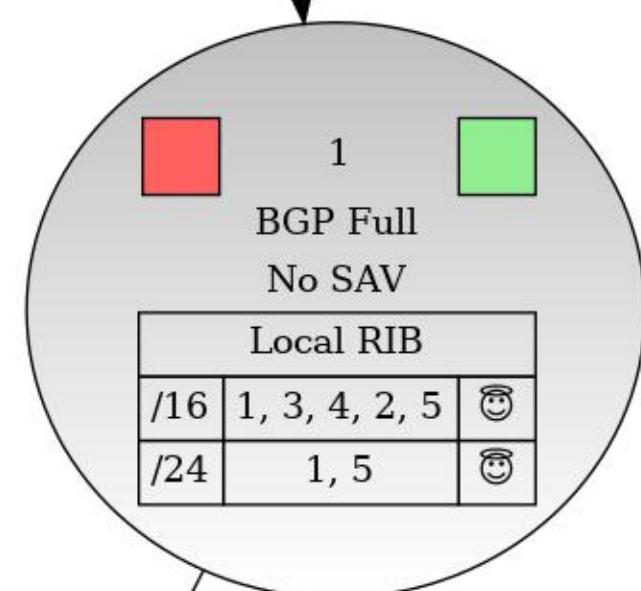
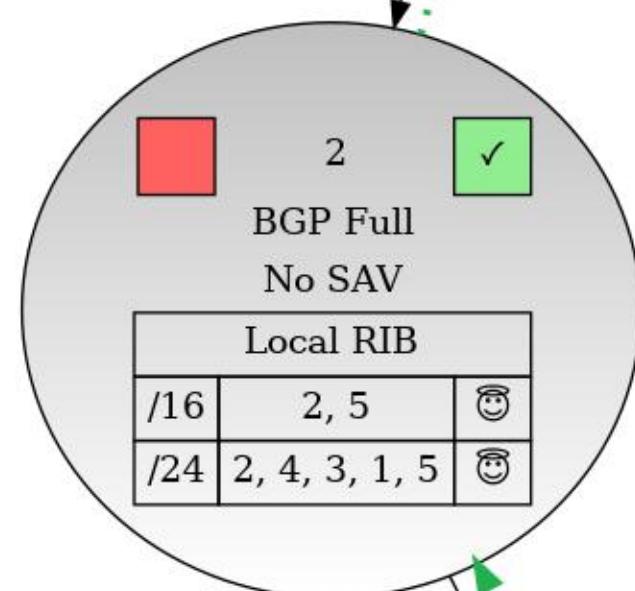
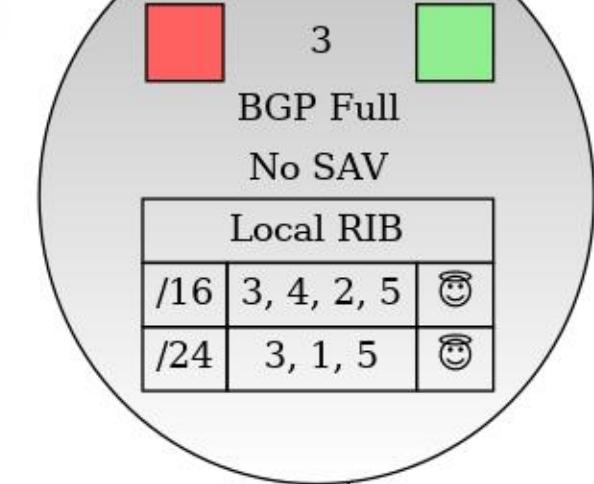
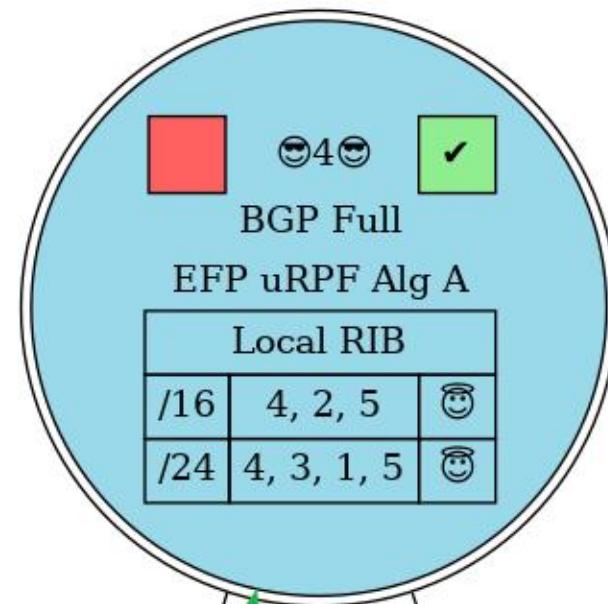
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(efp_a_002 Ground Truth)
Export 2 some (with replacement) passing for EFP Alg A

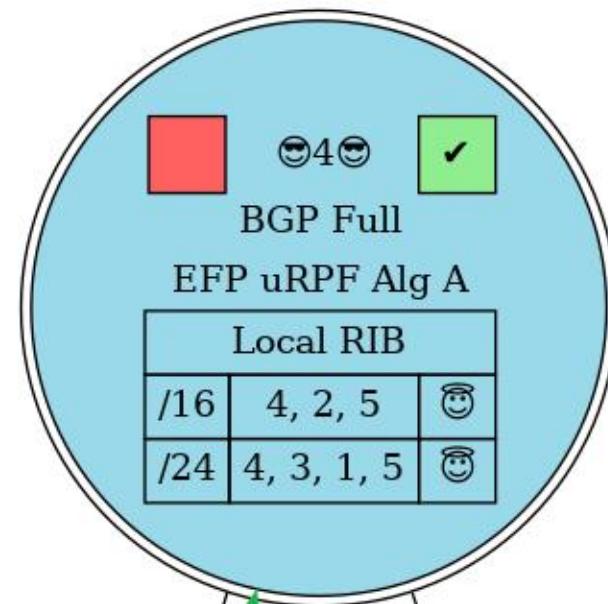
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



BGP Full
EFP uRPF Alg A

Local RIB

/16	4, 2, 5	😊
/24	4, 3, 1, 5	😊

/16 /24



BGP Full
No SAV

Local RIB
/16 3, 4, 2, 5
/24 3, 1, 5

/16 /24



BGP Full
No SAV

Local RIB
/16 2, 5
/24 2, 4, 3, 1, 5



BGP Full
No SAV

Local RIB
/16 1, 3, 4, 2, 5
/24 1, 5

/16 /24



BGPFULL E2S wR
No SAV

Local RIB
/24 5

/24

(efp_a_002)

Export 2 some (with replacement) passing for EFP Alg A

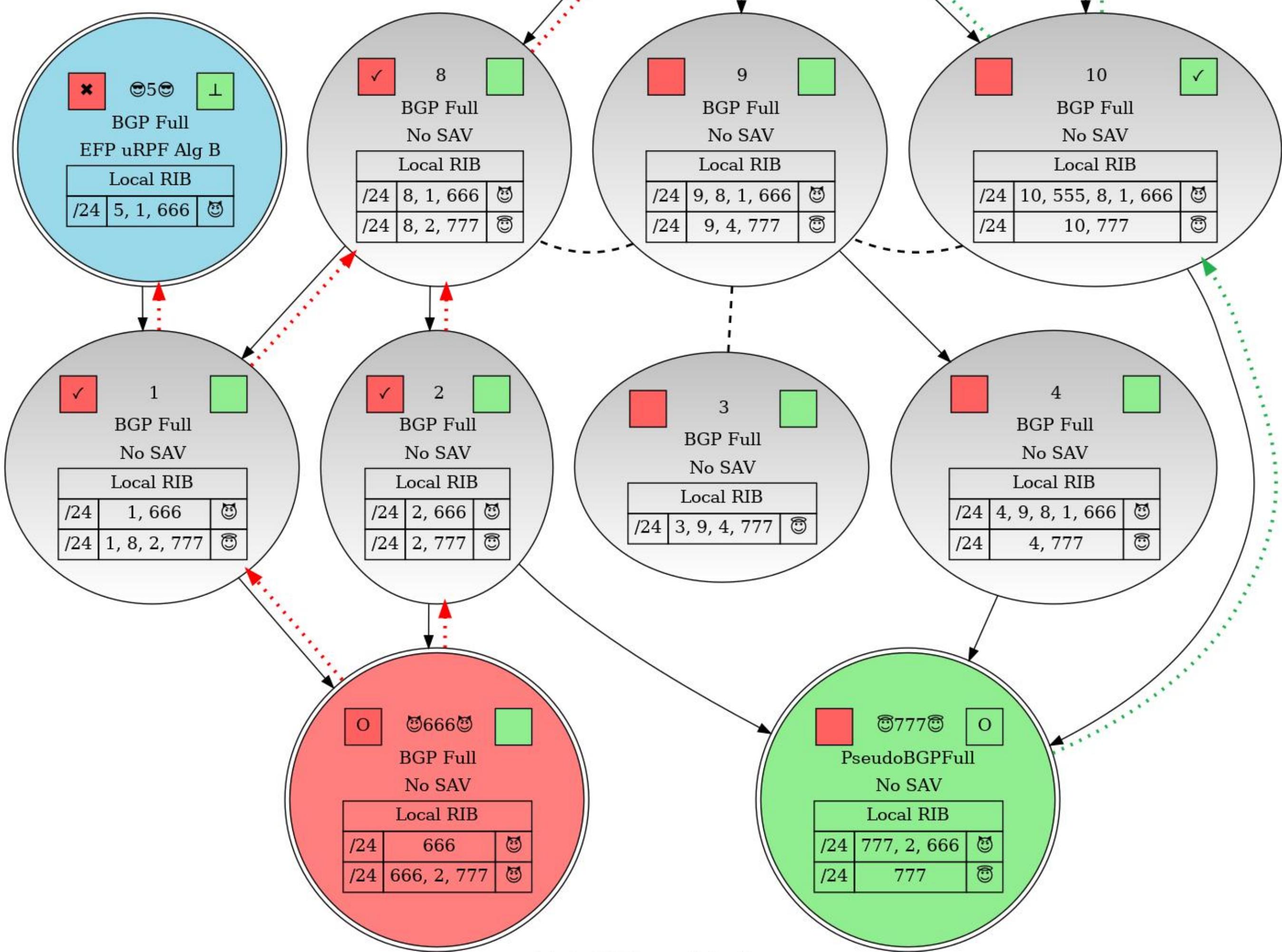
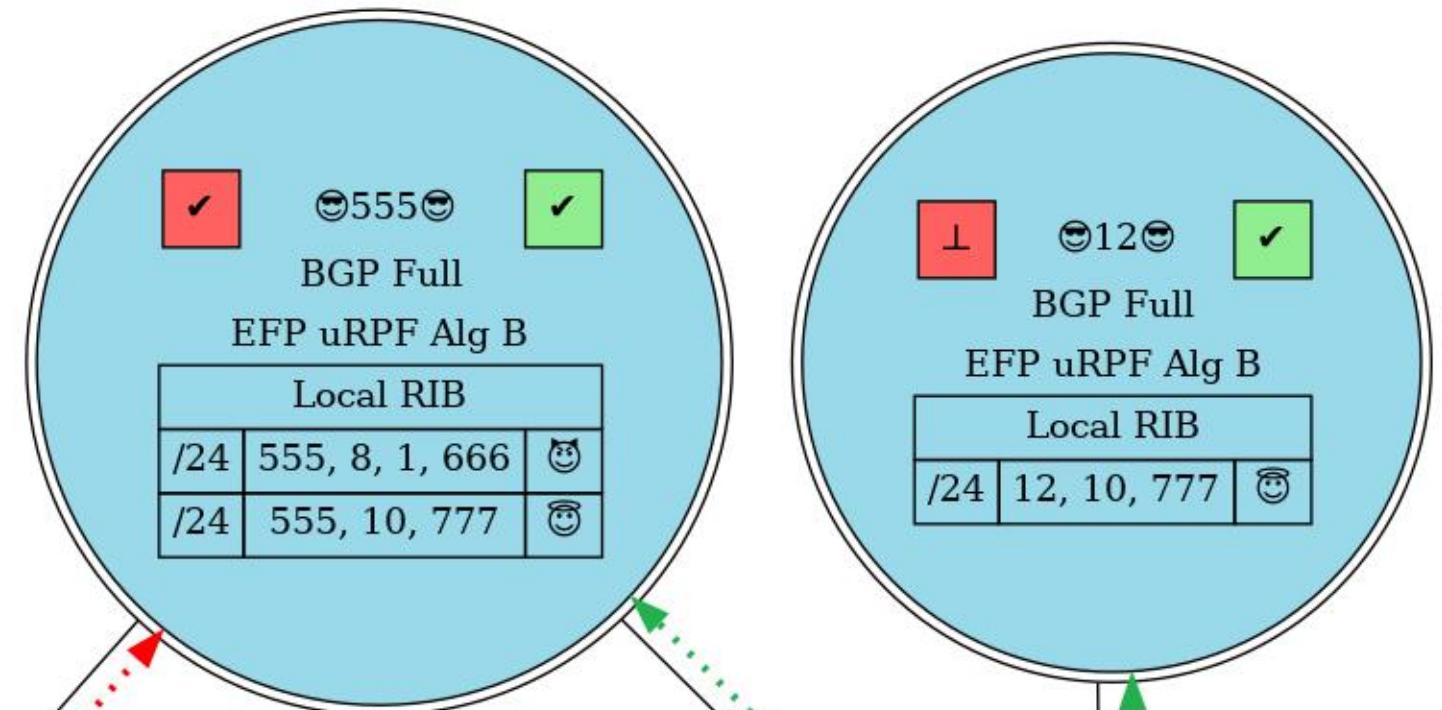
(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)

(Victim Outcomes)



(efp_b_000 Ground Truth)

Three reflectors running EFP uRPF Alg B, one disconnected from both victim and attacker

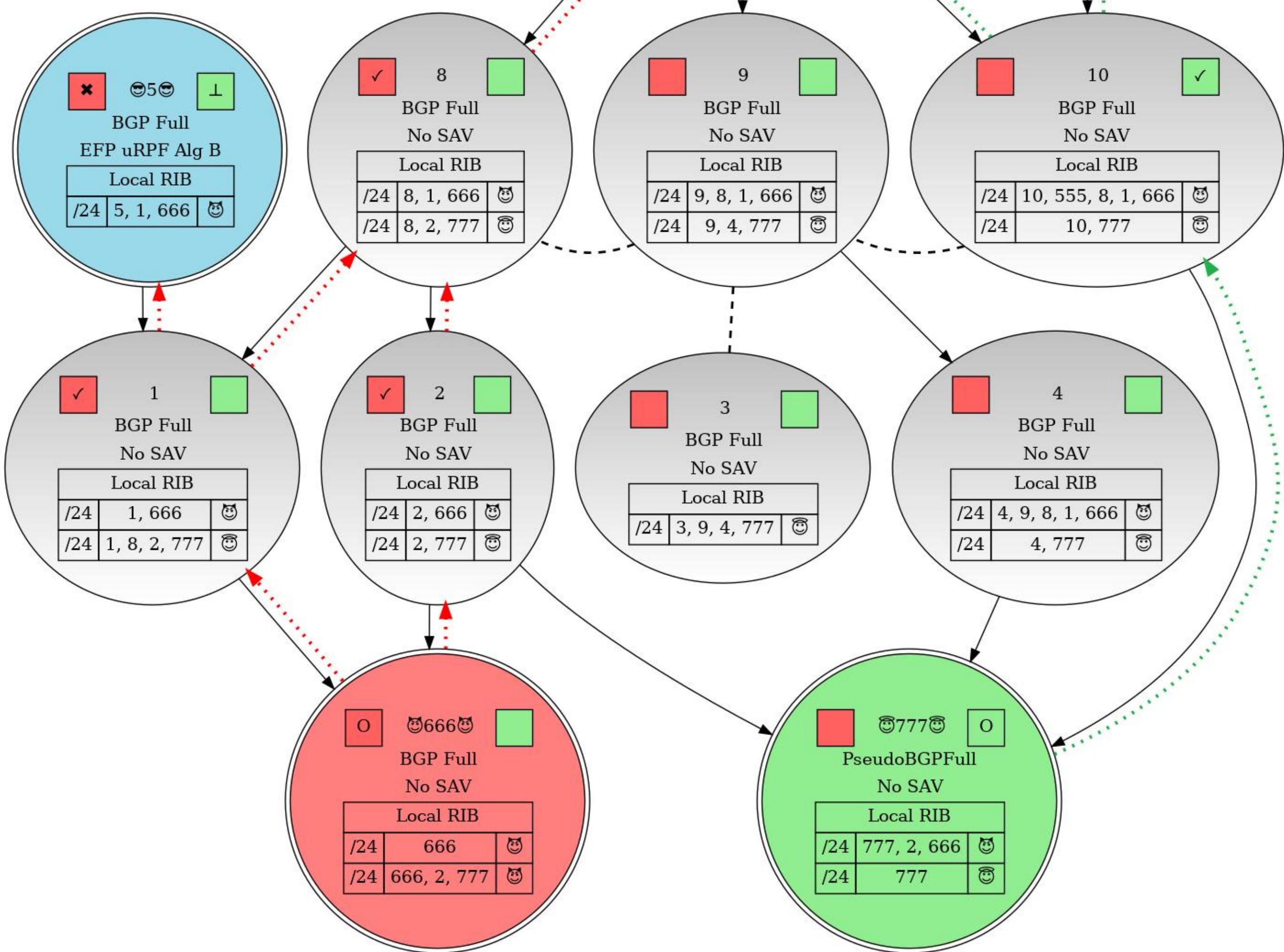
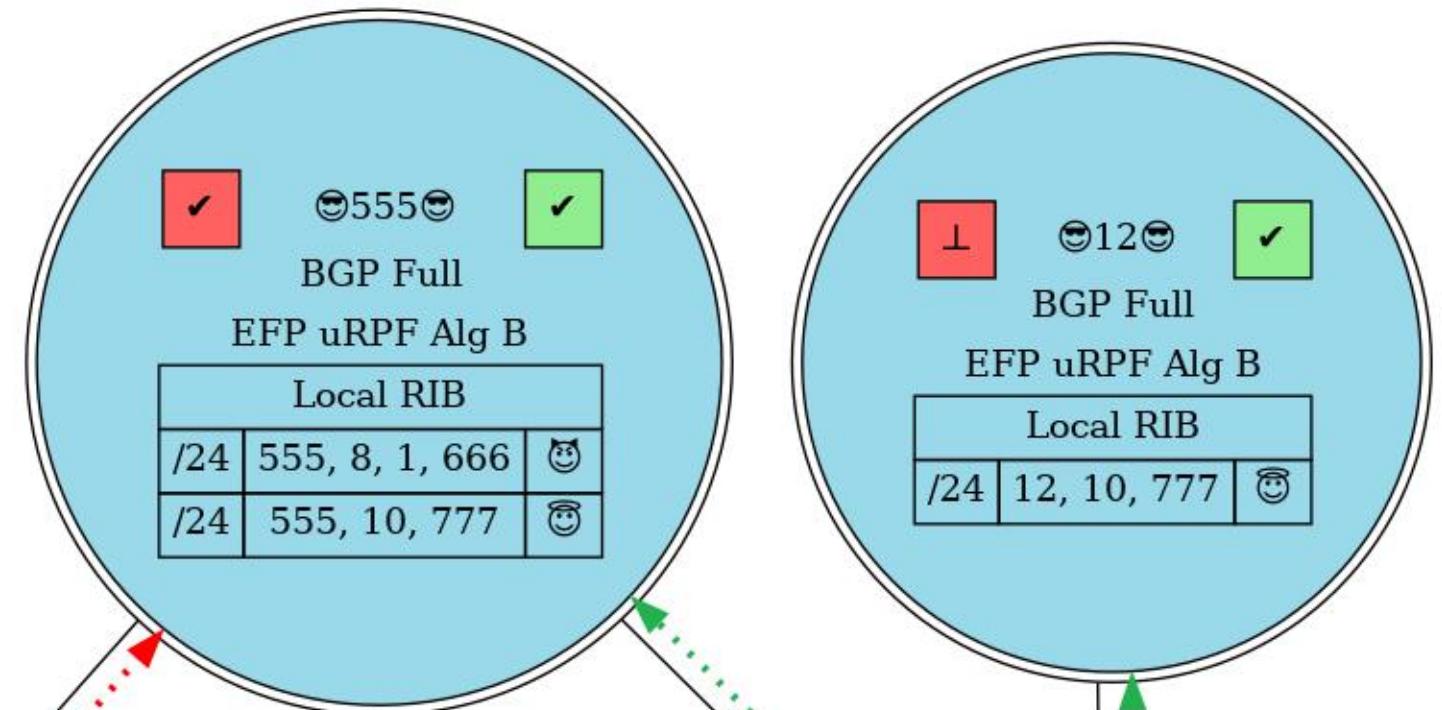
(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)

(Victim Outcomes)



(efp_b_000)

Three reflectors running EFP uRPF Alg B, one disconnected from both victim and attacker

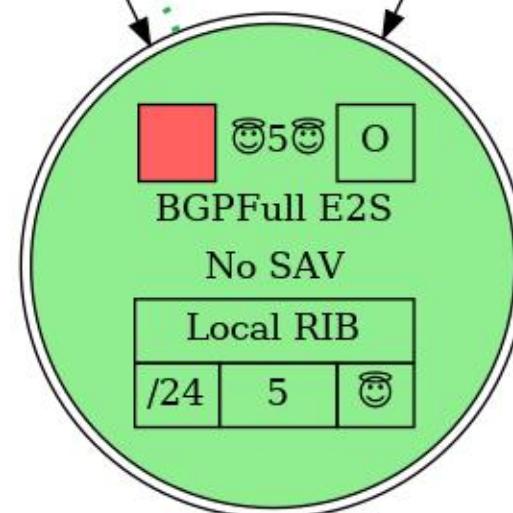
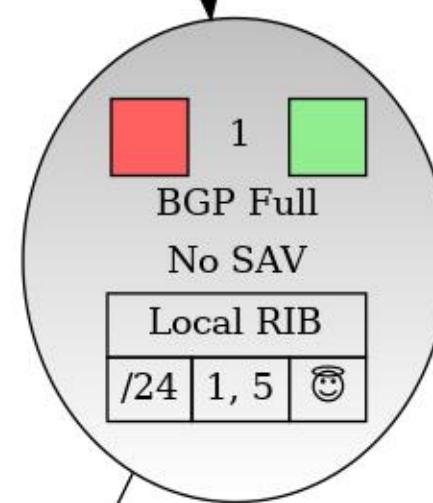
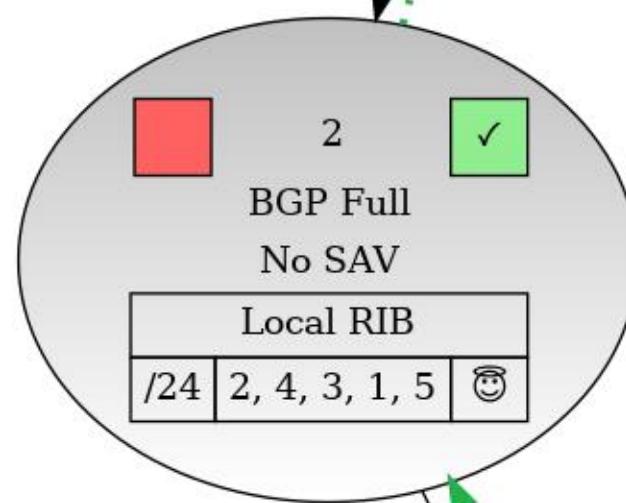
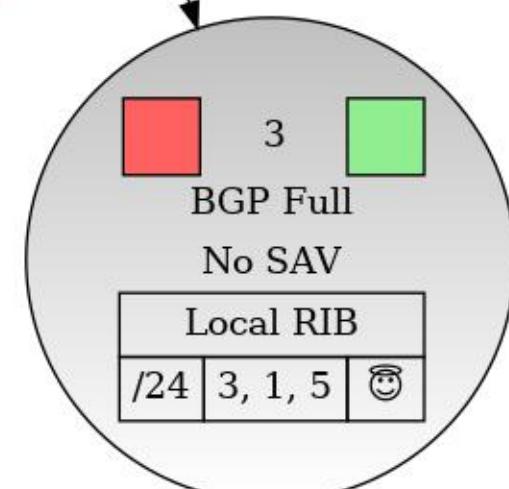
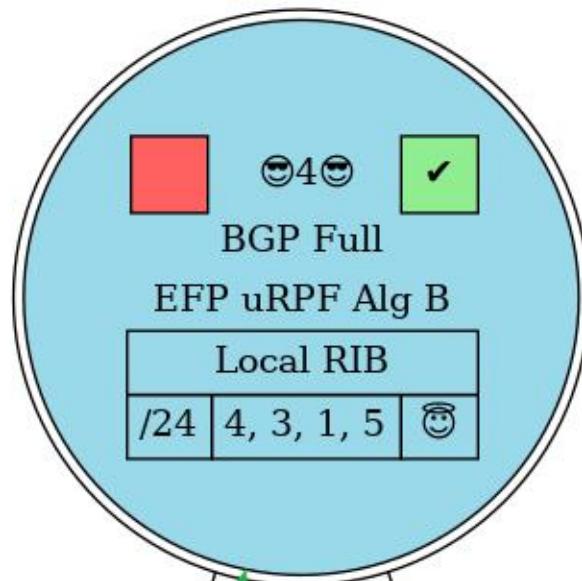
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(efp_b_001 Ground Truth)
Export 2 some passing for EFP Alg B (fails for Alg A)

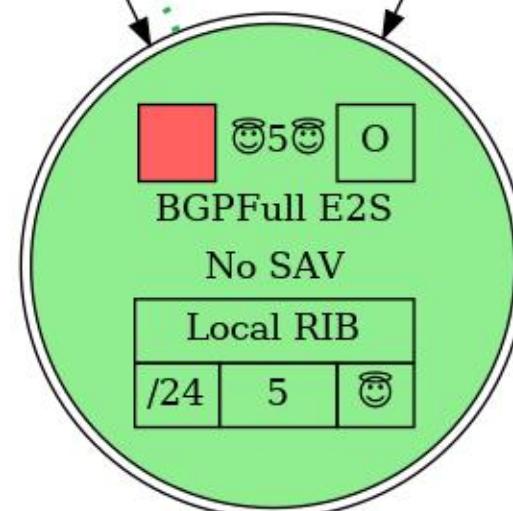
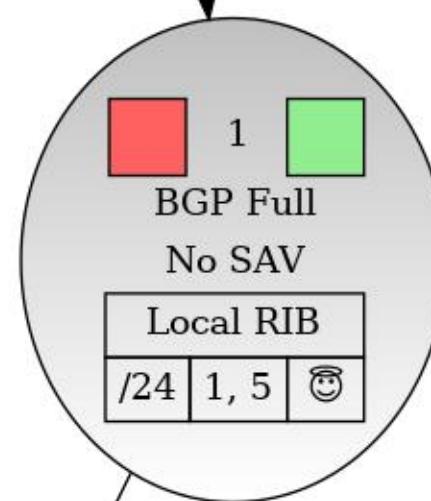
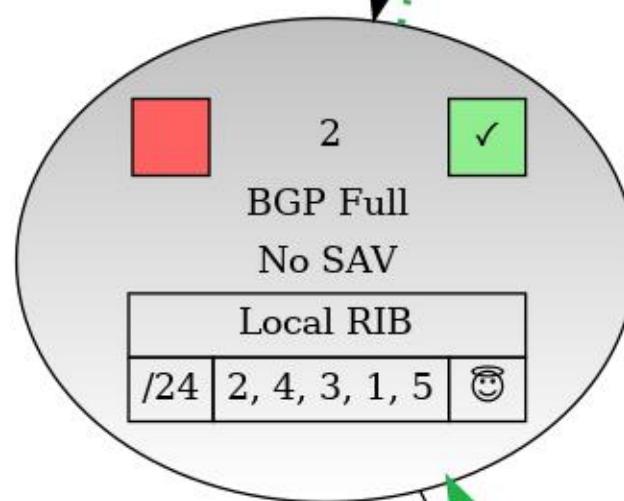
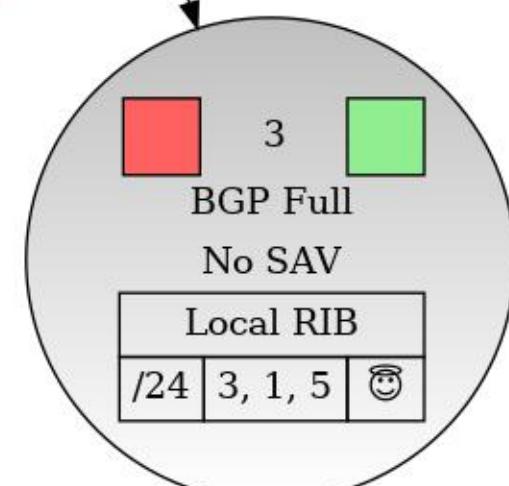
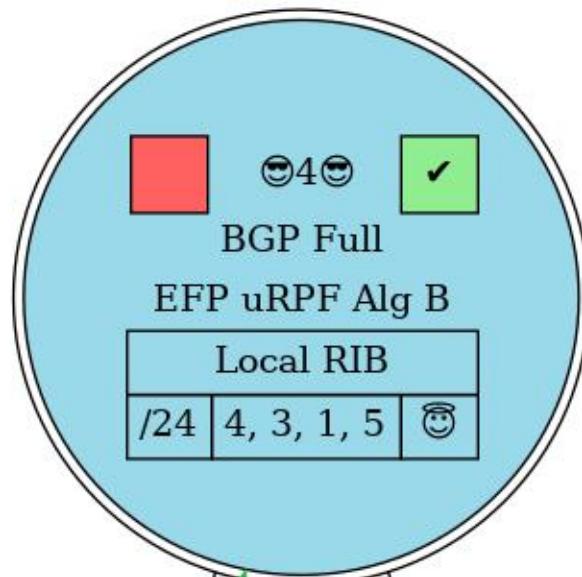
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	1
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



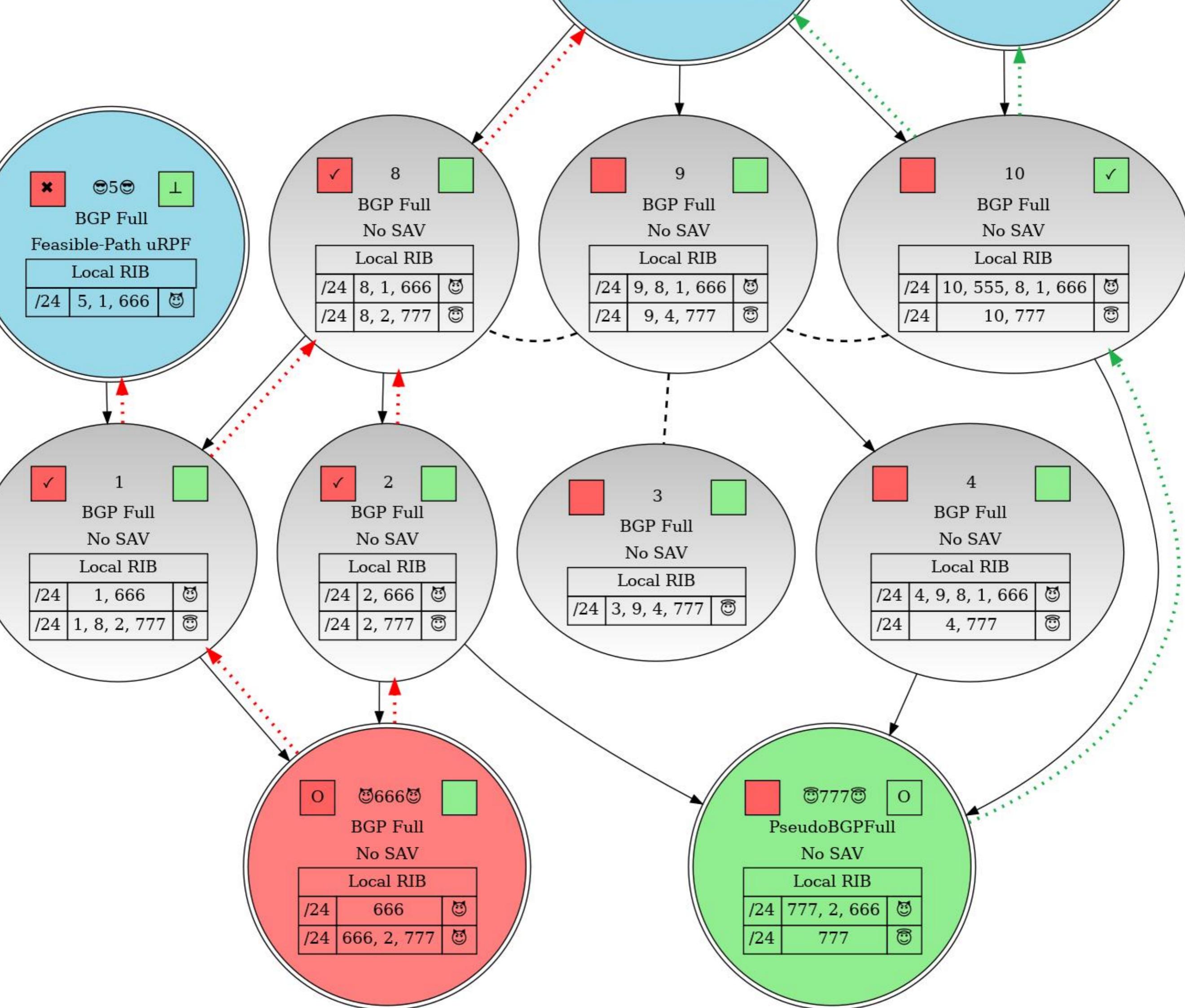
(efp_b_001)
Export 2 some passing for EFP Alg B (fails for Alg A)

(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



(fp_000 Ground Truth)

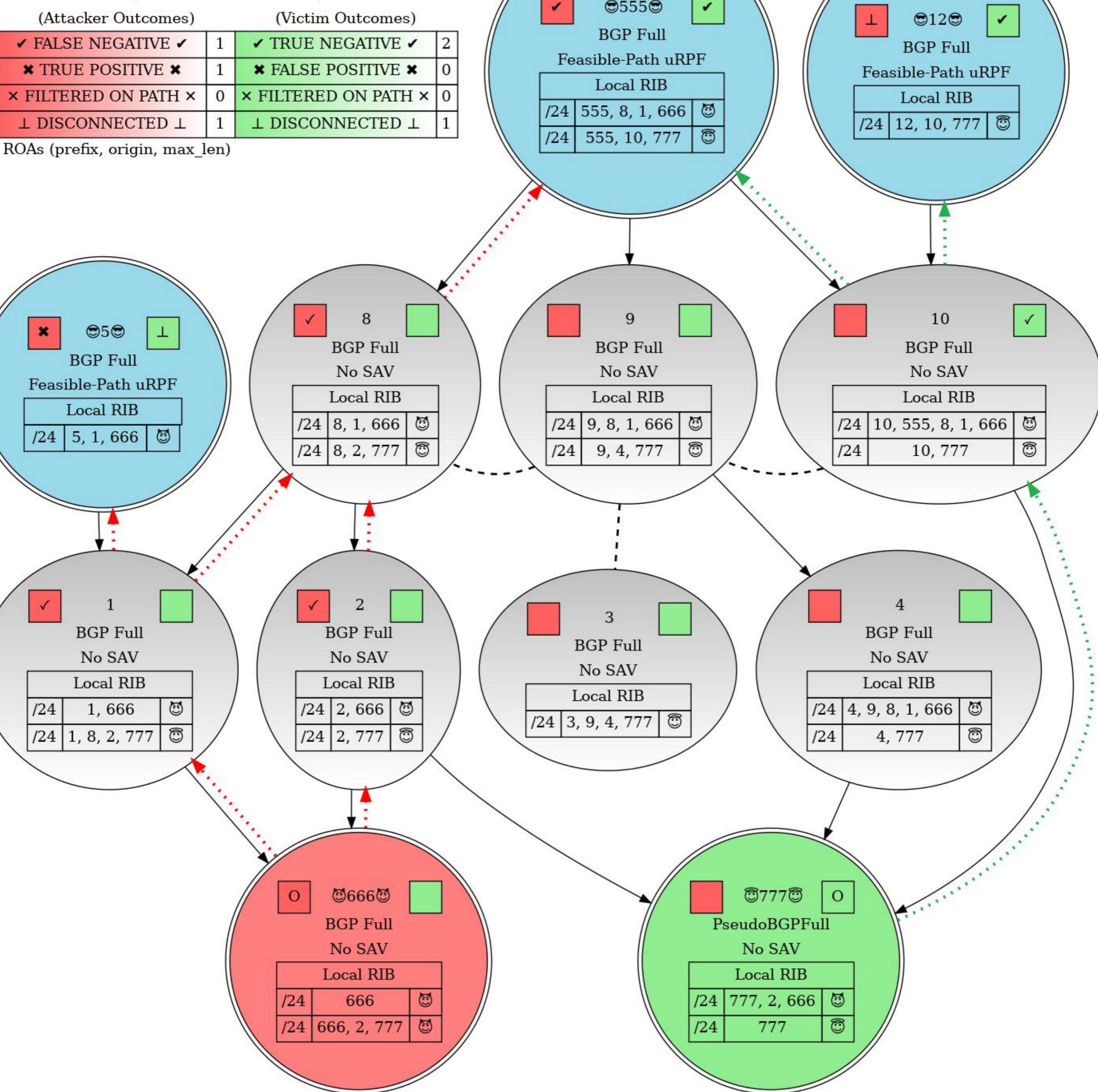
Three reflectors running Feasible Path uRPF, one disconnected from both victim and attacker

(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



(fp_000)

Three reflectors running Feasible Path uRPF, one disconnected from both victim and attacker

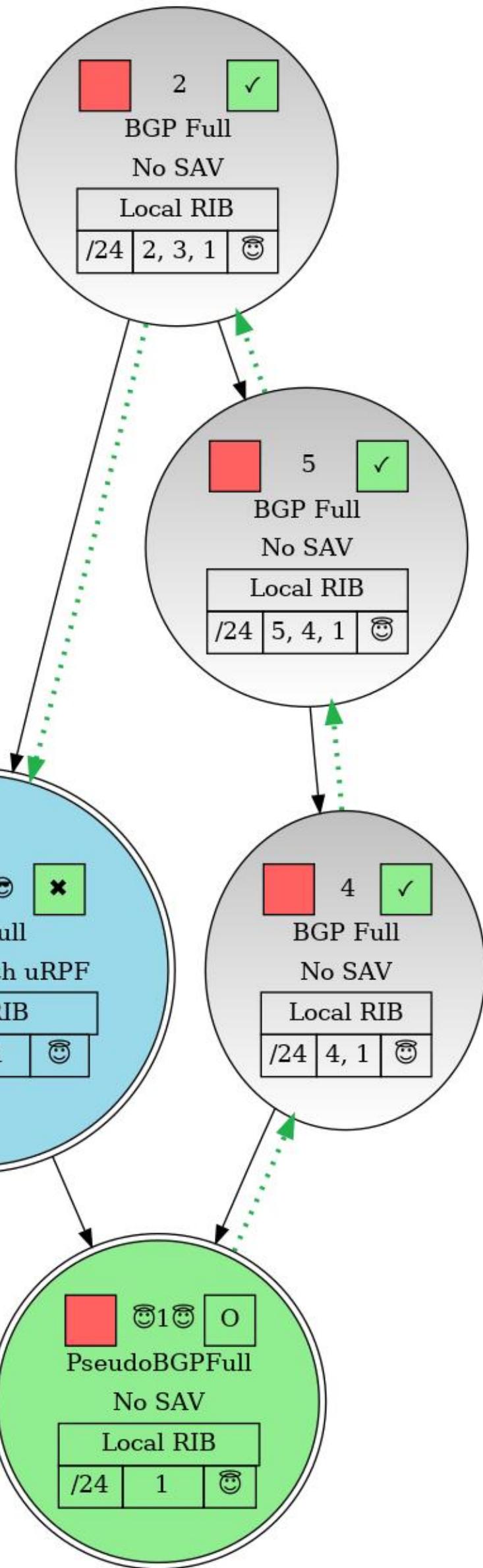
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(fp_004 Ground Truth)

False positive test for Feasible Path uRPF with Export-to-All

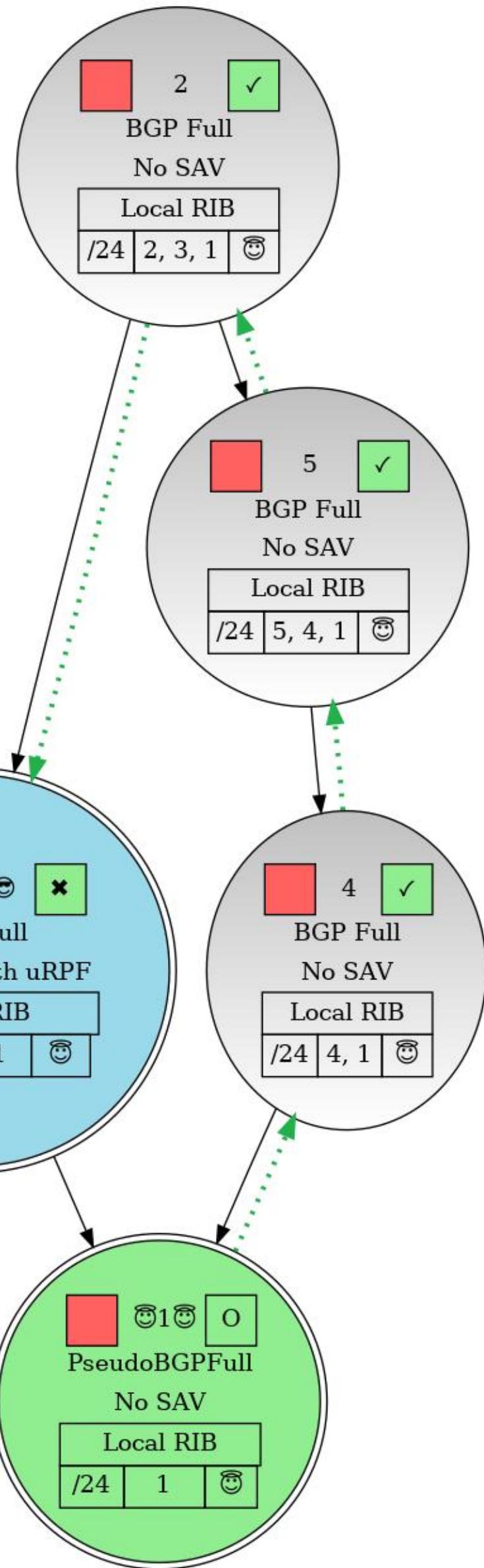
(Data Plane Outcomes)

(Attacker Outcomes)

(Victim Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(fp_004)

False positive test for Feasible Path uRPF with Export-to-All

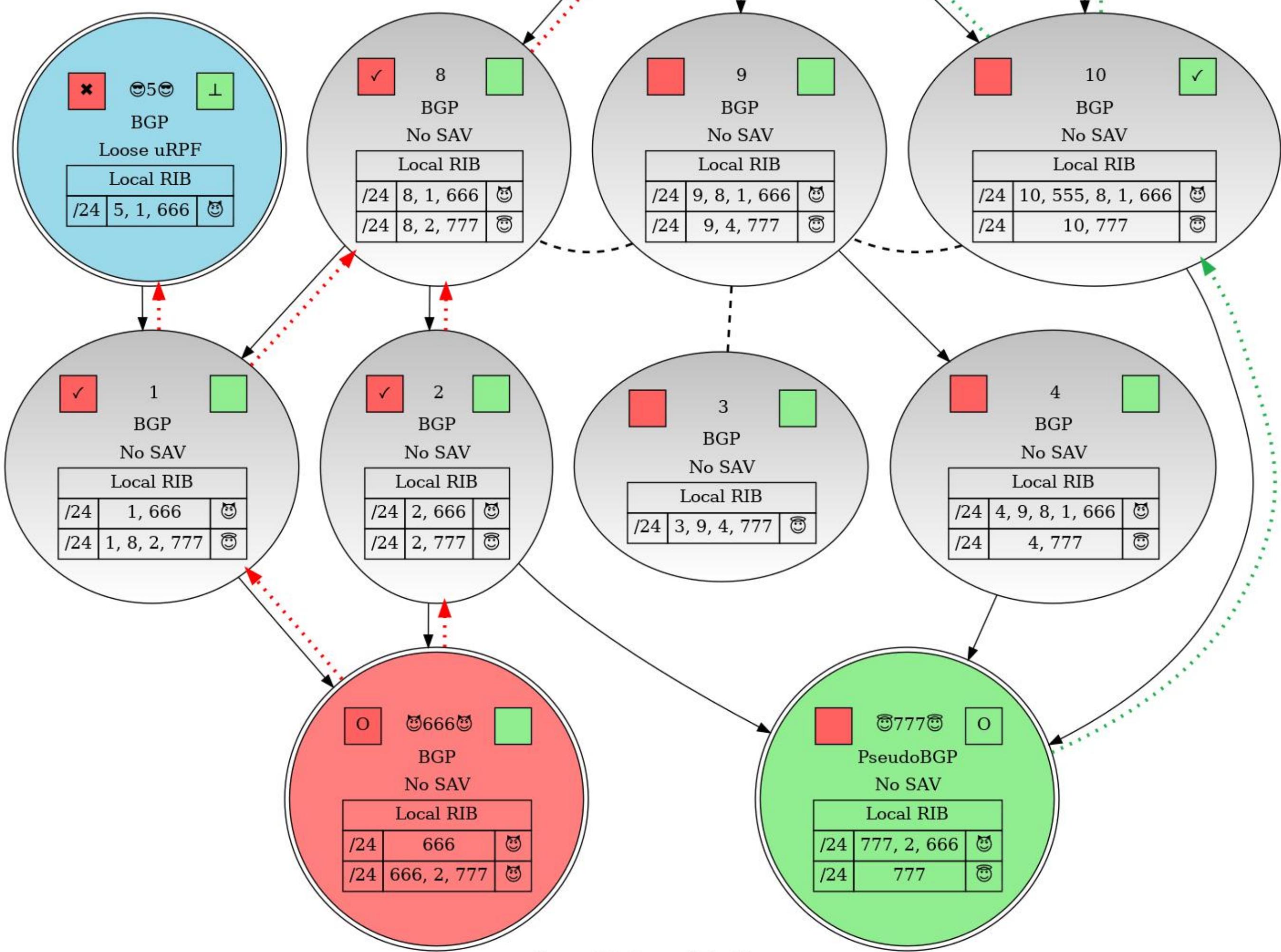
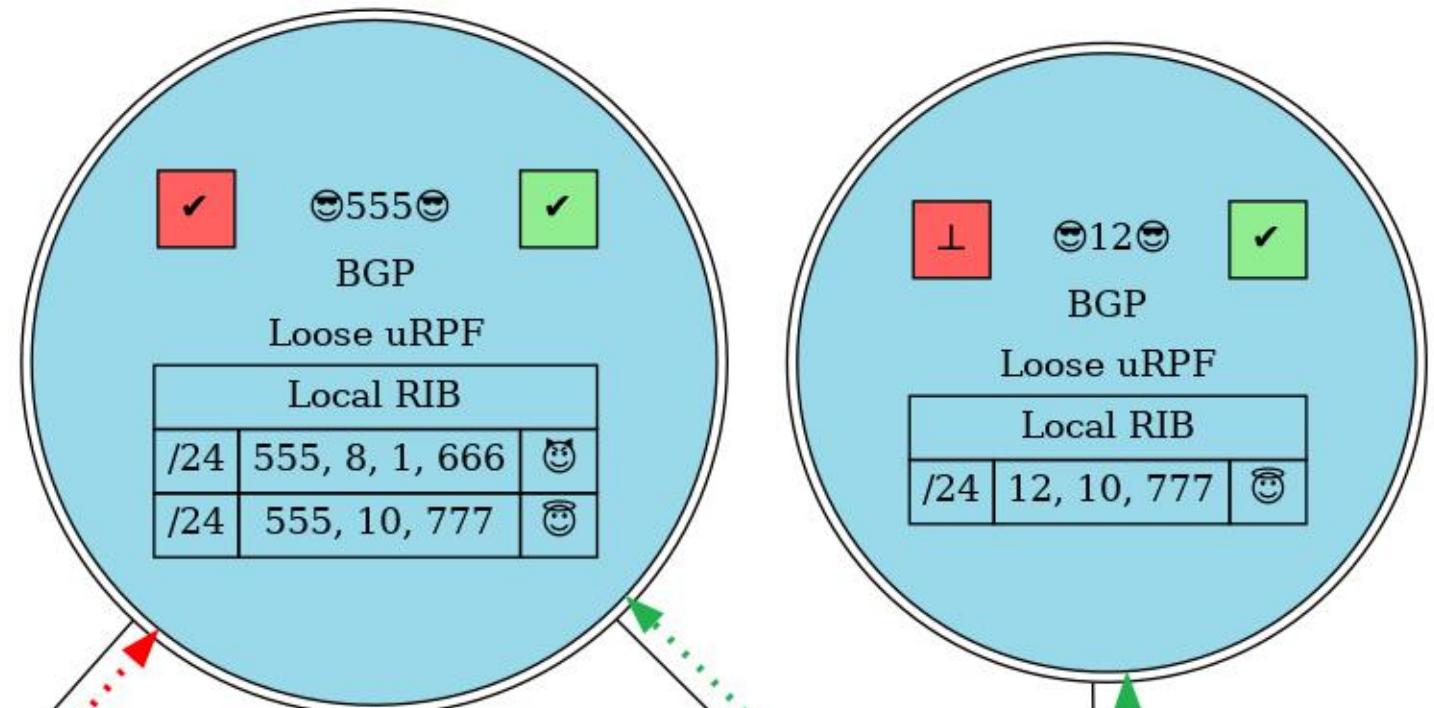
(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)

(Victim Outcomes)



(loose_000 Ground Truth)

Three reflectors running Loose uRPF, one disconnected from both victim and attacker

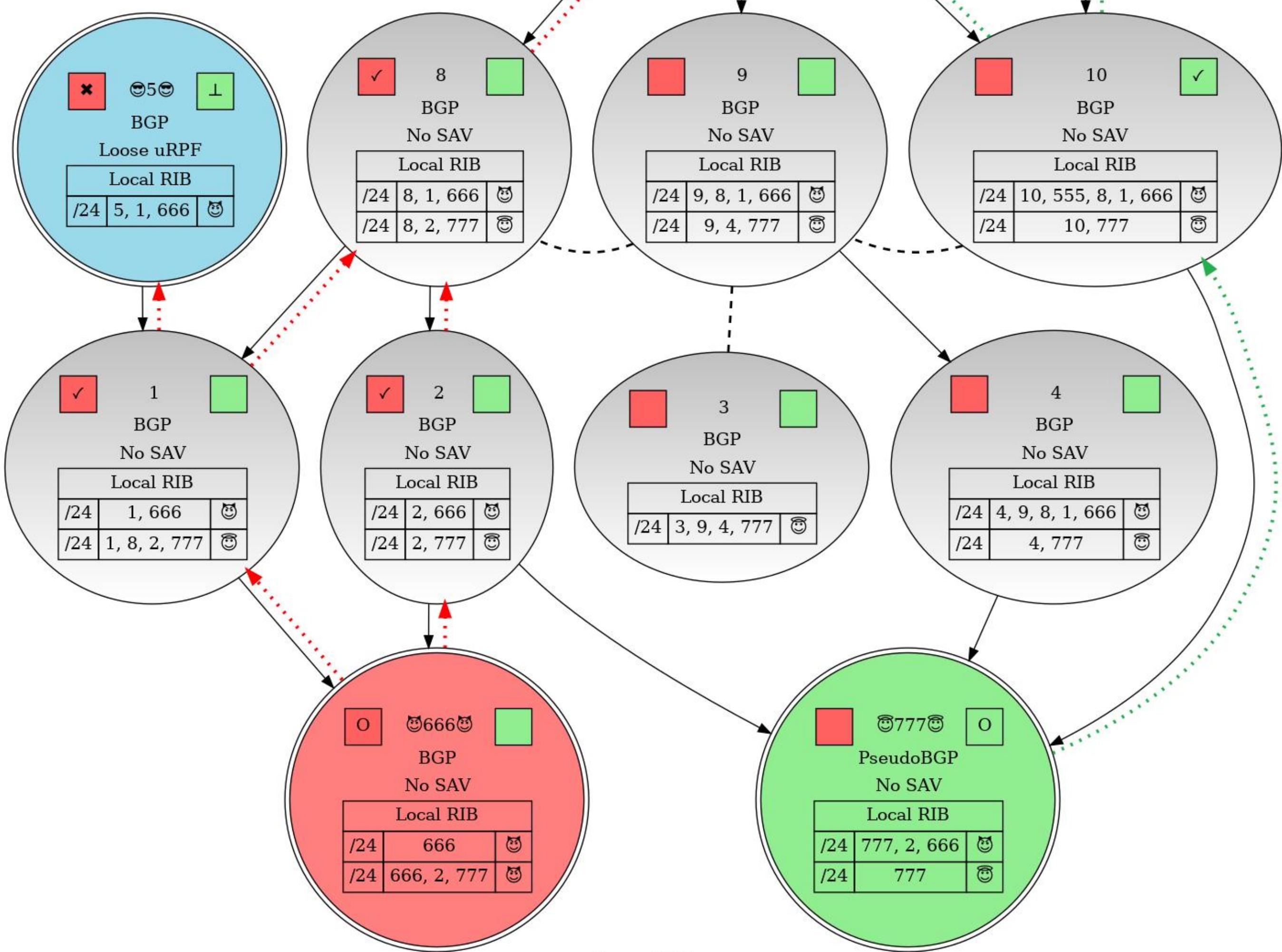
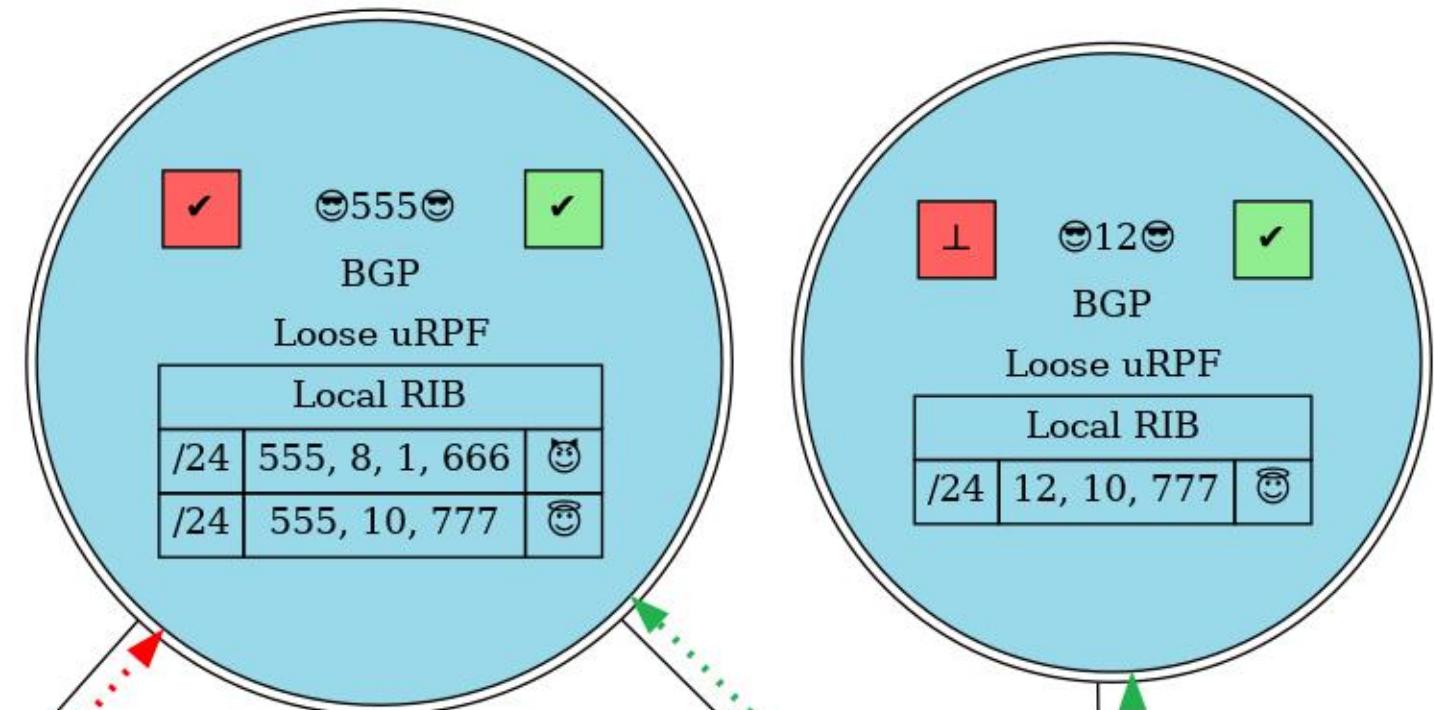
(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	1	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	1	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)

(Victim Outcomes)



(loose_000)

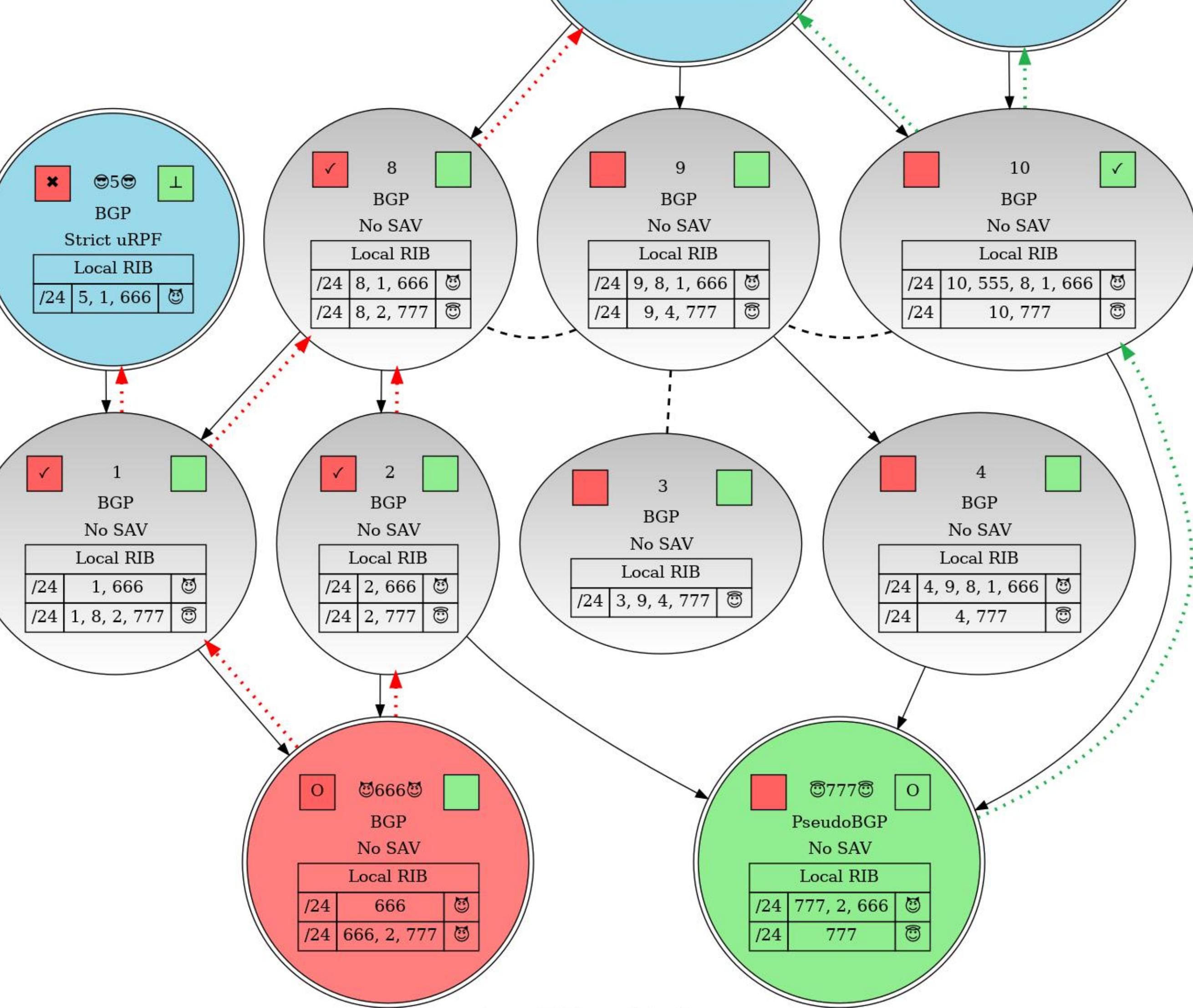
Three reflectors running Loose uRPF, one disconnected from both victim and attacker

(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	2	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



(strict 000 Ground Truth)

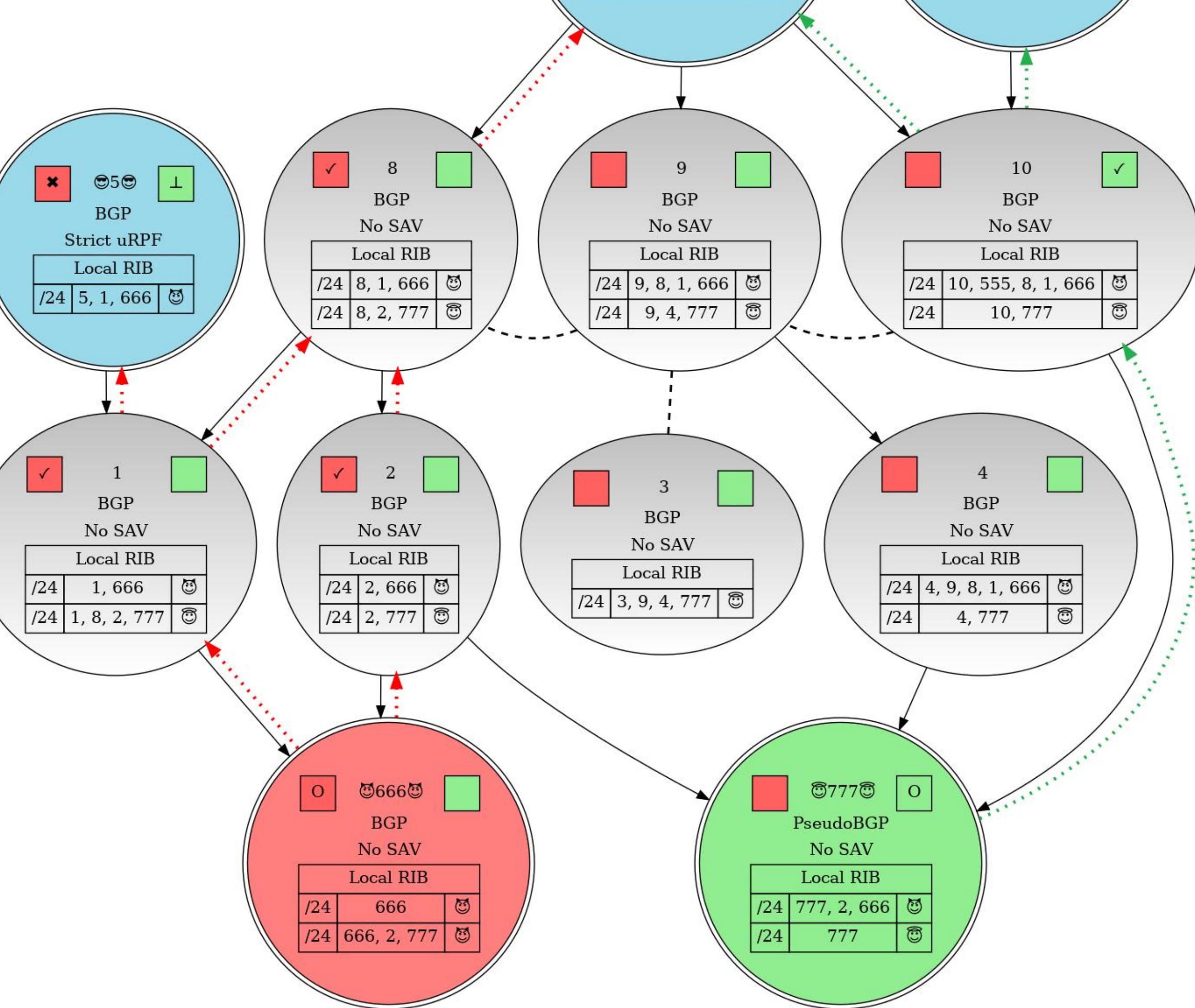
Three reflectors running Strict uRPF, one disconnected from both victim and attacker

(Data Plane Outcomes)

(Attacker Outcomes)

✓ FALSE NEGATIVE ✓	0	✓ TRUE NEGATIVE ✓	2
✗ TRUE POSITIVE ✗	2	✗ FALSE POSITIVE ✗	0
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	0
⊥ DISCONNECTED ⊥	1	⊥ DISCONNECTED ⊥	1

ROAs (prefix, origin, max_len)



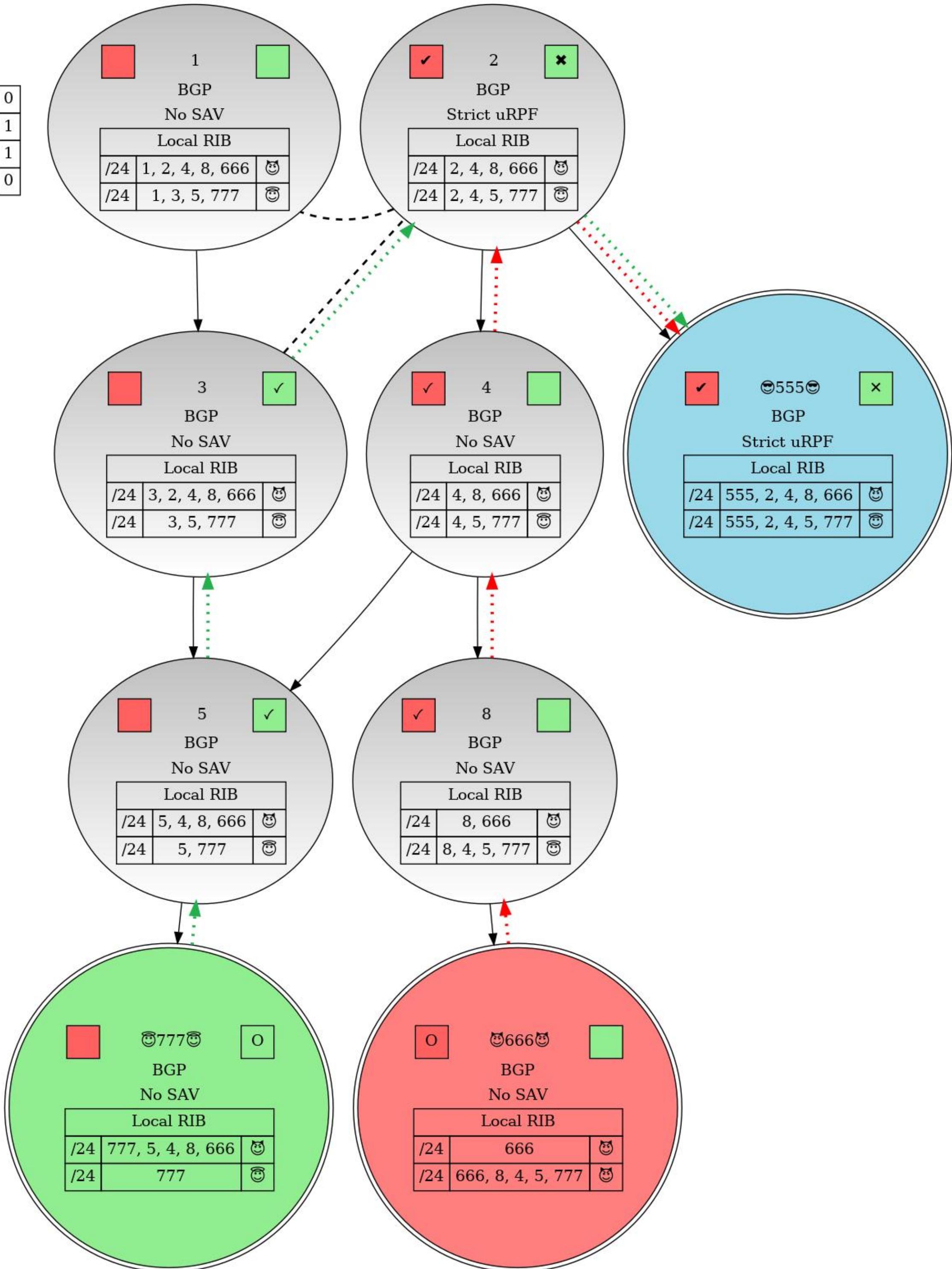
(strict_000)

Three reflectors running Strict uRPF, one disconnected from both victim and attacker

(Data Plane Outcomes)

(Attacker Outcomes)		(Victim Outcomes)	
✓ FALSE NEGATIVE ✓	2	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	1
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)

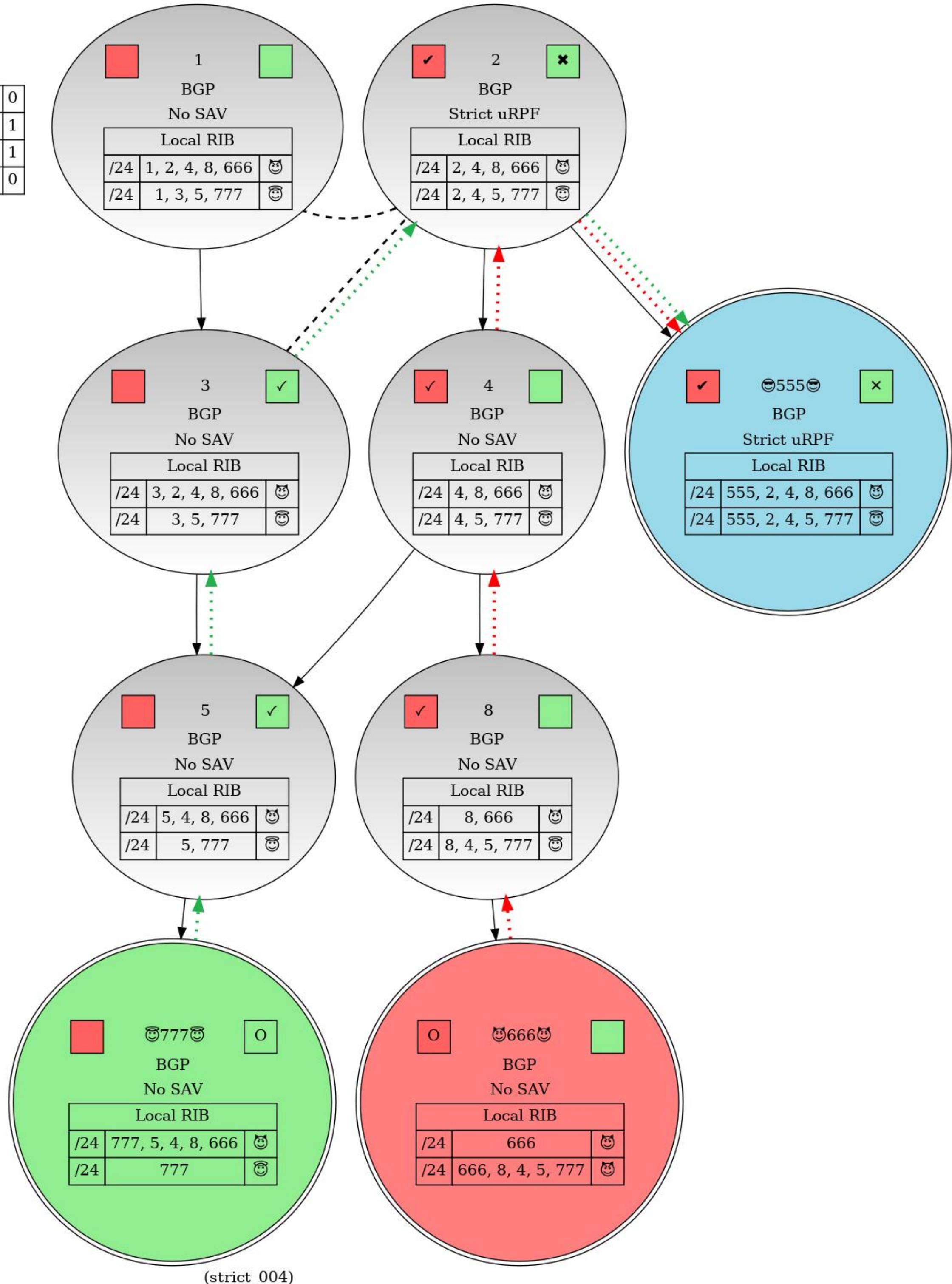


(strict_004 Ground Truth)
Strict uRPF on Asymmetric Route (Expecting False Positive)

(Data Plane Outcomes)

(Attacker Outcomes)		(Victim Outcomes)	
✓ FALSE NEGATIVE ✓	2	✓ TRUE NEGATIVE ✓	0
✗ TRUE POSITIVE ✗	0	✗ FALSE POSITIVE ✗	1
✗ FILTERED ON PATH ✗	0	✗ FILTERED ON PATH ✗	1
⊥ DISCONNECTED ⊥	0	⊥ DISCONNECTED ⊥	0

ROAs (prefix, origin, max_len)



(strict_004)
Strict uRPF on Asymmetric Route (Expecting False Positive)